U.S. Department
of Transportation
National Highway
Traffic Safety
Administration

People Saving People
http://www.nhtsa.dot.gov

DOT HS 808 582

February 1994

Interim Report

IVHS Countermeasures for Rear-End Collisions, Task 1

Volume II: Statistical Analysis

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 808 562		

4. Title and Subtitle IVHS Countermeasures for Rear-End Collisions Task 1 Interim Report Volume II: Statistical Analysis	**5. Report Date** February 25, 1994 **6. Performing Organization Code**
7. Author(s) Terrv Wilson	**8. Performing Organtzation Report No.**
9. Performing Organization Name and Address Frontier Engineering Advanced Program Division 7655 E. Redfield Drive, Suite 10 Scottsdale, AZ 85260	**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** DTNH2293-C-07326
12. Sponsoring Agency Name and Address Nabonal Highway Traffic Safety Administration (NHTSA) U. S. Department of Transportabon (DOT) 400 Seventh Street, S.W. Washington, DC. 20590	**13. Type of Report and Period Covered** Interim May 1993 - February 1994 **14. Sponsoring Agency Code** NRD-51

15. Supplementary Notes
NHTSA Contracting Officers Technical Representabve (COTR): Arthur Carter

16. Abstract
See Attached

17. Key Words	18. Distribution Statement
Collision Avoidance, Rear-end Collision, Crash Analysis, Performance Specifications, Causal Factors, Dynamic Situations, Human Factors	This document is available to the public from the National Technical Information Service (NTIS), Springfield, VA 22161

19. Security Classif. (of this report)	20 Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	98	n/a

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

EXECUTIVE SUMMARY / ABSTRACT

The attached report is from the NHTSA sponsored program, "IVHS Countermeasures for Rear-End Collisions," contract #DTNH22-93-C-07326. The program's primary objective is to develop practical performance guidelines or specifications for rear-end collision avoidance systems. The program consists of three Phases: Phase one: "Laying the Foundation" (Tasks l-4), Phase two: "Understanding the state-of-the-art" (Tasks 5 & 6), and Phase three: "Testing and Reporting" (Tasks 7-9). This work focuses on light (primarily passenger) vehicles and emphasizes autonomous in-vehicle based equipment (as opposed to cooperative infrastructure-based equipment.)

Phase I of this contract, Laying the Foundation, consisted of 4 Tasks: Task 1: a detailed analysis of the rear-end crash problem, Task 2: development of system-level functional goals, Task 3: hardware testing of existing technologies, and Task 4: development of preliminary performance specifications or guidelines. The goals of Tasks 1, 2 and 3 were to develop the background needed to write the preliminary performance guidelines (Task 4).

Task 1, a detailed analysis of the rear-end Crash Problem, consisted of analysis, both clinical and statistical, of available mass accident data bases, some of which include the pre-crash variables, and an initial human factors study. The goal here was to identify, determine the nature of, and quantify the causes of rear-end type crashes. A report volume was written for each of these areas.

The Task 1 Interim Report consists of six volumes. This Volume, Volume I, "Summary," presents background information, an overview of the framework used to analyze the rear-end collision problem, an overview of the initial human factors studies, and summarizes the clinical and statistical analysis of the accident data. This report (all volumes) forms the foundation for the work in the later stages of the contract. Descriptions of Volumes II - Vl are as follows:

a. Volume II, "Statistical Analysis," presents the statistical ana lysis of rearend collision accident data that characterizes the accidents with respect to their frequency, severity, thne and place of occurrence, the vehicle, and the involved drivers. Data for this Volume includes NHTSA's Fatal Accident Reporting System (FARS), NHTSA's General Estimates System (GES), and some state accident data files for recent years.
b. Volume III "1991 NASS CDS Clinical Case Analysis," presents the results of the detailed analysis of cases from NHTSA's 1991 National Accident Sampling System (NASS) Crashworthiness Data System (CDS) crash data.
c. Volume IV, "1992 NASS CDS Clinical Case Analysis," presents the results of the detailed analysis of 200 cases from the 1992 NASS CDS crash data including the new pre-crash variables.
d. Volume V, "1985 NASS Analysis, ' presents the results of the analysis of the 1985 NASS crash data. Data from 1985 was selected for analysis because it provided more insight into roadway variables that are no longer available in the current CDS or GES databases.
e. Volume VI, "Human Factors," presents the results of the initial human factors literature review and study.

From this detailed analysis of the accident databases a framework of the dynamic situations of rear-end collisions was developed and used to analyze the rear-end collision problem. From an in-depth analysis of the dynamic situations it was discovered that most rear-end collisions occur with the following vehicle traveling at a constant velocity and the lead vehicle decelerating to a stop, i.e. the close-following or platooning situation. It was determined that the primary causal factors for rear-end collisions were inattention and following too closely. Also determined was a list of preliminary specification information.

The results presented during Phase I, including the Preliminary Performance Guidelines or Specifications, are based on work carried out with limited interactions with the academic, research, and industry communities, any conclusions drawn from the results presented must bear this in mind.

Phase II goals include a detailed state-of-the-art review of technologies related to rear-end collision avoidance systems and the design of a test bed system. Phase II will complete in June 1996. Phase III goals include the construction and test of the test bed system, the generation of the final performance guidelines or specifications, and the final reporting on all aspects of the project. Phase III will finish in early 1998. Work continues throughout Phase II and III to add to, and to refine, these preliminary performance guidelines or specifications. Numerous items still need to be determined (TBD) throughout the remainder of the research.

Key words: Collision Avoidance, Rear-end Collision, Crash Analysis, Performance Specifications, Causal Factors, Dynamic Situations, Human Factors.

STATISTICAL ANALYSIS

TABLE OF CONTENTS

STATISTICAL ANALYSIS

LIST OF FIGURES

LIST OF FIGURES CONTINUED

STATISTICAL ANALYSIS

LIST OF FIGURES CONTJNUED

LIST OF FIGURES CONTINUED

LIST OF FIGURES CONTINUED

STATISTICAL ANALYSIS

LIST OF TABLES

LIST OF TABLES CONTINUED

LIST OF TABLES CONTINUED

PREFACE

This report is intended to characterize rear-end traffic accidents in the United States with respect to their frequency, their severity, time and place of occurrence, and the vehicle and drivers involved to supplement the NHTSA reports'[1,2]. Additional statistical information presented within this report is important to some aspects of system design and analysis and in system trade-offs and benefits analysis. Data sources for this work include the NHTSA Fatal Accident Reporting System (EARS), various aspects of the National Accident Sampling System (NASS) particularly the General Estimates System (GES), state data files from Michigan, Texas, and Washington, and some reference to the literature.

The report is organized as follows:

- A discussion of the data sources used in the NHTSA reports referenced above (Section 1)
- A presentation of tabular material concerning the frequency of rear-end collisions as observed in several state accident files. (Section 2)
- The drivers in rear-end collisions-age, gender, and actions. (Section 3)
- The vehicle types in rear-end collisions-frequency of involvement by type, differences between fatal and non-fatal collisions, and who hit whom. (Section 4)
- Time of occurrence of rear-end collisions. (Section 5)
- Analysis of the 1992 NASS GES with the five new pre-crash variables. (Section 6)
- Summary (Section 7).

As discussed in Section 1, one of the problems in analysis of accident data files is that the data files themselves often have shortcomings. An attempt has been made to qualify the data by both internal and external comparisons. Some uncertainties remain, partly from

---

1 Knipling, Ronald R., J. S. Wang, H. M. Yii "Rear-End Crashes: Problem Size Assessment and Statistical Description," NHTSA, May 1993

2 Knipling, Ronald R. et al, "A Front-end Analysis of Rear-end Crashes," Presented at the IVHS America Second Annual Meeting, Newport Beach, California, May 17-20,1992

the sample size limitations but also from known and unknown biases in the various data sets. Injury data, at the national level, is confounded by a considerable variability in reporting practice among the states. Police reported crash occurrence frequencies as estimated by the General Estimates System are low compared with FHWA estimates. There has been a trend in recent years in many states to report a smaller fraction of minor accidents with time. Since rear-end collision severity is, on the average, lower than most other types of accidents, it is likely that the proportion of unreported rear-end crashes of this type is significant.

It should be possible to perturb the planning models to learn whether their outcomes are sensitive to changes in the total rear-end accident count, or to the crash and injury severity distributions. The existence of the missing data is recognized in the NHTSA report and the present report contains a description of some of the characteristics of the missing cases that should make such perturbation possible.

An example of the more complete information from in-depth case reviews is presented in connection with the observed distributions of avoidance maneuvers. This kind of information is important to the development of rear-end collision models and ultimately to the design of the driver interface of collision warning and avoidance systems.

The relative frequency of rear-end collisions as estimated by the GES is similar to that observed in individual state files. Roughly one-quarter of all reported accidents involve a rear-end collision, and nearly one-third of all accident-involved vehicles are in these crashes. The estimate of the cost of traffic tie-ups proceeds from an estimate of accident frequency and is a useful statistic. Rear-end collisions constitute a large fraction of the accident problem.

The remainder of this volume presents information about rear-end accidents, the drivers in these accidents, and the vehicles involved. Data are drawn from the major federal files, but are confirmed and augmented somewhat by information from several state files.

SECTION 1
CRITIQUE OF PROBLEM SIZE ASSESSMENT

1.1 INTRODUCTlON

Completeness and accuracy of the data from which "size of the problem" estimates have been made are considered in this section of the report. Numerous national, state and local data files were accessed to show inconsistencies in the national data files that NHTSA used (GES and FARS) to estimate the problem size and statistical makeup in their report.

The NHTSA FARS database is a census. It should be considered a relatively complete record of U.S. fatal accidents, and any random biases that occur within the data file are presumed small enough to be neglected. This is discussed further in Section 1.2.

The GES database is as close to a complete analysis file as is available, and it appears robust enough to allow reasonable estimates of the characteristics of the rear-end collisions recorded. However, certain biases are evident within the GES, and those biases plus suggested adjustments to some of the NHTSA estimates are described in Sections 1.3 and 1.4.

1.2 FARS

FARS is considered to be a relatively complete record of U.S. fatal accidents. It is a nominal census and therefore, not subject to statistical testing. FARS has been successfully validated against public health sources for the purpose of confirming that it is complete. While it is correct to note that there is no random component of error in the FARS estimates, there may well be bias errors such as coding some angle accidents as rear-end collisions. For the present, the magnitude of these errors is unknown and presumed small enough to be neglected. The FARS file does exhibit some of the police injury inconsistencies observed in other data, but this is usually not of great importance in the analysis of fatal accidents.

1.3 GES

The National Accident Sampling System General Estimates (NASS-GES) is based on a sample of police reports collected by agents in a number of primary sampling areas in the

U.S. These are subsequently coded to a common form by a NHTSA contractor and placed in a computer file along with weighting factors to permit national estimates of accidents and accident-related factors. An excellent coding manual has been developed, and there is an interacting computer editing procedure to prevent illogical codes.

Blincoe[3] has reported that the GES estimates of accident frequency (without regard to type) are about 15% lower than the frequencies estimated by the published FHWA tables of accident frequency in the various states. Several explanations are offered for these discrepancies, but they are all complicated by variations in reporting practice among the states. Blincoe goes into considerable detail to justify his findings. The main reason for perhaps giving credence to his estimates is that they derive from a compilation of accident census data acquired from the states rather than from a sample.

Some studies[4,5,6] have reported missing data (cases not included in the conventional police report files and not represented in GES) in the range of fifty percent and that the missing cases are biased in many ways. Fife and Cadigan[7] concluded there is substantial variation in the quality of accident data from state to state, "suggesting a need for caution" in comparing state performance based on non-fatal crashes. In the referenced paper, they looked at city to city variation within a state (Massachusetts). They suggest

---

3 Blincoe, Lawrence J and Barbara M Faigin, The Economic Cost of Motor Vehicle Crashes, 1990, NHTSA Technical Report DOT HS 807876, 1990

4 ***Scott,*** R.E. and P.S. Carroll, ***Acquisition of Information on Exposure and on Non-Fatal Crashes, Volume II Accident Data Inaccuracies*** Highway Safety Research Institute, University of Michigan, May 197 1

5 Hauer E. and A.S. Hakkert, "Extent and Some Implications of Incomplete Accident Reporting," ***Transportation Research Record NI 185*** (1988) pp. l-10.

6 McGuire F.L. "The nature of bias in official accident and violation records." ***Journal of Applied Psychology, (57),*** 300-305. (1973)

7 Fife D. and R. Cadigan "Regional variation in motor vehicle accident reporting: Findings from Massachusetts." ***Accident Analysis & Prevention,*** (21), 193-l 96 (1989)

that data on local reporting performance be obtained and used to adjust jurisdictional comparisons.

Barancik and Fifes compared hospital records of treatment in hospital emergency rooms in northeastern Ohio with police-reported motor vehicle traffic collision injuries recorded in the Ohio Department of Public Safety reports. They reported that matched police reports were found for only 442 of 882 cases (50%). This data is not claimed to be representative of the country as a whole, although the authors refer to similar reports that suggest that the problem is universal.

Greenblatt[9] et al studied missing data in connection with the NASS program. Their study estimated that 79 percent of injury accidents and 54 percent of property-damage-only accidents were reported in NASS. The telephone part of the survey asked respondents to recall accidents over the past four months and it was followed up by a prospective study with a mailed return for the following four months.

Over a period of the last 20 years, there have been many changes in the standards and practices for police accident reporting. Some examples are given in the following paragraphs.

In many large cities police seldom attend the scene of minor accidents. When accidents are reported authorities ascertain whether they are needed to move vehicles or to assist with the injured and they often suggest that the drivers report the accident at the nearest police station or that the drivers complete a driver report form and submit that to the state. In most states these driver report forms are not processed into the state accident data file.

In Texas, sometime around 1977, there was a major shift in accident reporting. Prior to that time Texas law required that police report virtually all accidents. In 1977 the threshold was changed by statute to set a reporting threshold of $250 in damage. At the

---

8 Barancik J.I. & D. Fife, "Discrepancies in Vehicular Crash Injury Reporting: Northeastern ***Ohio*** Trauma Study ***IV," Accident Analysis and Prevention,*** Vol. 17, No. 2 1985 pp 147-154).

9 Greenblatt, J., M.B. Merrin, D. Morganstein & S. Schwartz, "National Accident Sampling System Nonreported Accident Survey," US Department of Transportation, National Highway Traffic Safety Administration DOT HS-806198, November 1981

same time there was a reinterpretation of the law so that the police subsequently only reported accidents that were investigated, and they used their judgment about which cases to investigate. Texas has used the TAD[10] damage severity scale for a long time. This is a seven-point scale with a value of "1" for very minor damage, 7 for a maximum crush. The Texas reporting change shows up in the TAD damage scale distributions plotted in Figure 1.3-1.

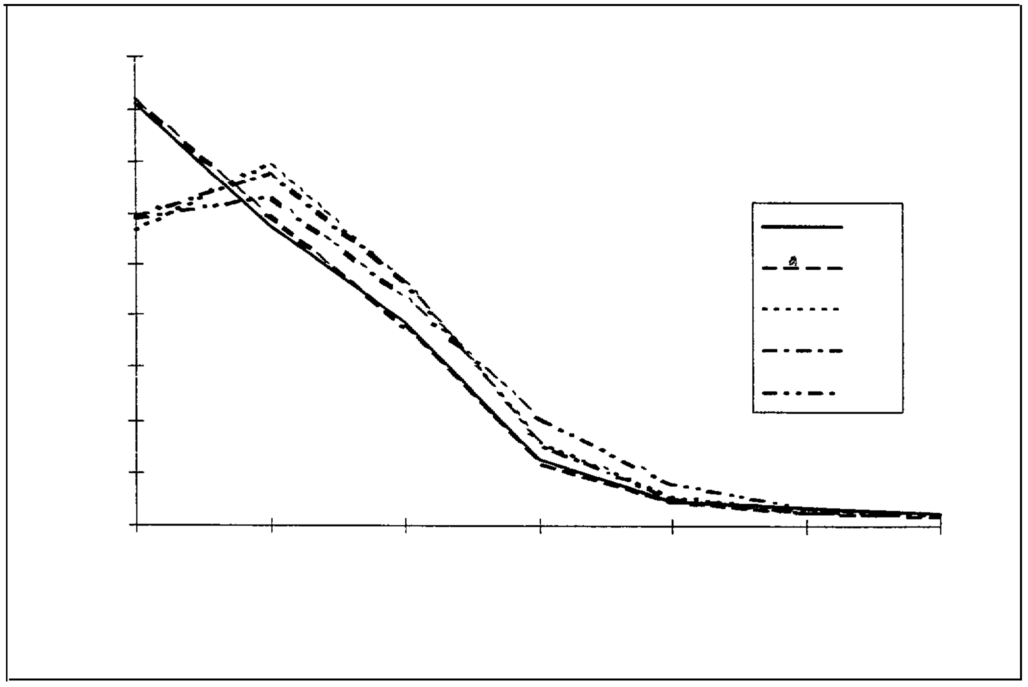

Figure 1.3-l TAD Damage Distribution in Texas Accident Data, Five Separate Years;

In 1977, Pennsylvania changed the threshold for reporting accidents from a dollar limit to a tow-away limit plus any accidents with injuries. The result was a sudden drop in the number of reported accidents per year. Loukissas and Mace[11] considered the problem of

10 "Vehicle Damage Scale for Traffic Accident Investigators," published by National Safety Council with the assistance of the University of North Carolina Highway Safety Research Center.

11 Loukissas P. & J. Mace, "Conversion of Pennsylvania accident data to account for change in reporting." Pennsylvania Transportation Institute, University Park. 88 p. Report No. PTI-8219. (1982)

comparing older data with the newer data for evaluation of road safety modifications. They reviewed a sample of about 12,000 accidents (8,000 of which involved Property Damage Only, PDO), and determined which of these would have been reported under the new rule. They found that the percentage of PDO tow-aways varied considerably by accident type. Fifty-five percent of the fixed object accidents resulted in tow-aways while only twenty-three percent of the rear-end accidents resulted in tow-aways. Based on this, it appear that a large percentage of the non-reported accidents are rear-end collisions.

The Detroit data for front-damaged cars involved in rear-end collisions is plotted against the same subset for the rest of Michigan in Figure 1.3-2 (The Detroit curve has been "normalized" by multiplying each entry by 0.6 so as to force the two curves to match at the right side for comparative purposes.). The area at the left between the two curves represents those cases that are missing because the police have chosen to not investigate and report low severity crashes. Note that about 46% of the front-damaged rear-end collision vehicles are at TAD-l for the state area suggesting that the average rear-end crash is of low severity. The significant information in this graph is obtained by noting the discrepancy in the TAD-l and TAD-2 accidents. This graphical estimate indicates that Detroit reports about 42% fewer rear-end collisions than they would have if they met the same reporting standard as the remainder of the state.

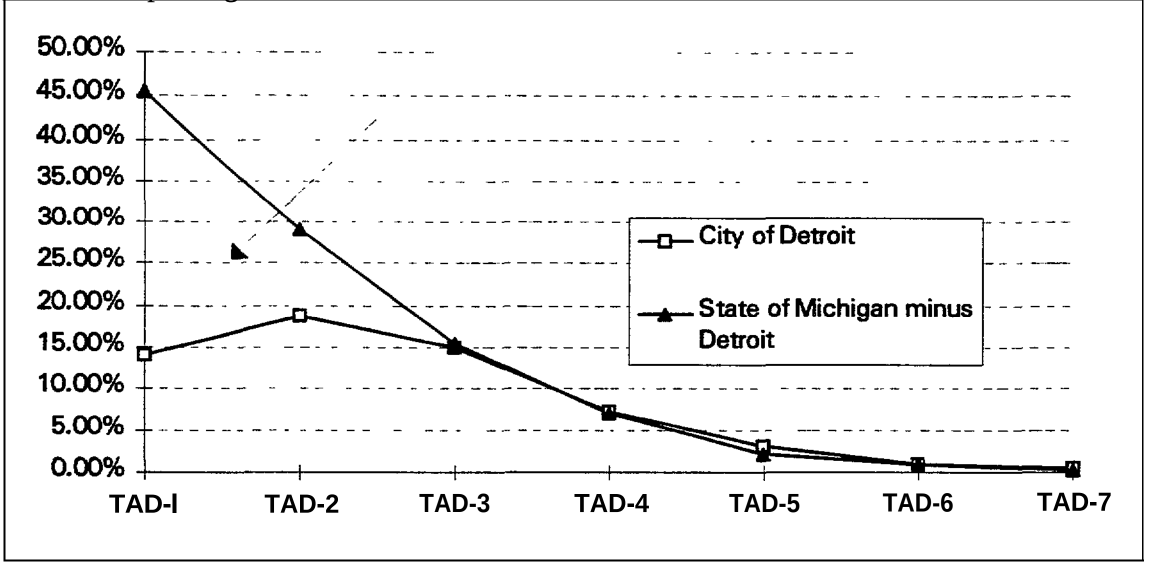

Figure 1.3-2 Comparison of Detroit And State of Michigan TAD Distributions, With A Measure of The Proportion of Missing Cases in Detroit. (Front-Damaged Vehicles in Rear-End Collisions)

There is other evidence of the practice of not reporting minor collisions in urban areas. The Insurance Institute for Highway Safety[12] surveyed drive-in claims adjustment operations in Houston, Los Angeles, Washington, DC, and Chicago. The 16 claims centers involved were run by four major insurers: Allstate, GEICO, Nationwide, and State Farm. Of interest is the finding that only thirty-nine percent of those interviewed said that they had reported the crash to police. About one-fifth of the claims originated in parking lots. Taking out the parking lot accidents about half of the remainder probably had sufficient damage to be reported to the police in many jurisdictions (80 percent of the claims exceeded $500). The authors noted that damage claims for rear-end crashes were substantially higher when there was bumper mismatch-pickup trucks or vans in collision with passenger cars.

In another insurance industry report concerning repair estimate information, Werner and Sterback[13] did not provide any estimate of the availability of police reports, but they did note that front-to-rear collisions accounted for 29 percent of ‘their 2-vehicle accident claims. They also report that, “Many vehicle accident involvements go unreported to insurers because of the absence of coverage or minor damage that does not exceed deductible amounts.” In addition, many vehicle owners choose not to file claims when they were at fault because some companies will increase their premiums substantially after settlement.

Injuries are recorded in the GES using the police KABCO coding scheme. “K” indicates killed, “A” an incapacitating injury, “B” a visible injury that is not incapacitating, “C” an invisible injury or complaint of pain. “0” is uninjured. GES (as well as many states) also codes two unknown categories: Injured but severity unknown, and Unknown if injured. The unknowns account for about 4% of the persons involved in reported accidents.

One problem with police injury reporting is that different police agencies (particularly different states) have interpreted the injury coding scheme in different ways. The States’

---

12 Wells, JoAnn K, S. W. Gouse, and Alan F. Williams, “Collision Types and Damage to Cars Brought to Insurance Drive-In Claims Centers”’ Insurance Institute for Highway Safety, November 1991

13 Werner, John. V, and Steve J. Sterback, “Use of Repair Estimate Information to Evaluate Physical Damage Severity in Two-Car Accidents, SAE 841254

Model Motorist Data Base Data Element Dictionary for Traffic Records Systems (ANSI D-20.1) uses these definitions:

> Possible Injury ***("C")*** is ***any reported or claimed injury which is not included below, i.e., momentary unconsciousness.***
>
> Non-Incapacitating Injury ("B") is ***any evident injury which is not fatal or incapacitating, i.e., abrasions, bruises, minor lacerations.***
>
> Incapacitating Injury ("A") is ***any non-fatal injury which prevents the victim from walking, driving,*** **or** ***other normal activity, i.e., severe lacerations, broken bones.***

The assignments of these codes are done by police officers, usually at the scene and without benefit either of medical training or follow up information. The coding scheme was intended to be applied this way.

The problem in interpreting the GES data is that some jurisdictions are rather liberal in handing out "A" injury codes, and some are rather stingy. Figure 1.3-3 is based on data acquired directly from state files and shows the proportion of A, B and C injuries in the total state records for several states from which GES data is obtained. Note that Alabama has nearly twenty times the frequency of 'A" injuries as does Pennsylvania.

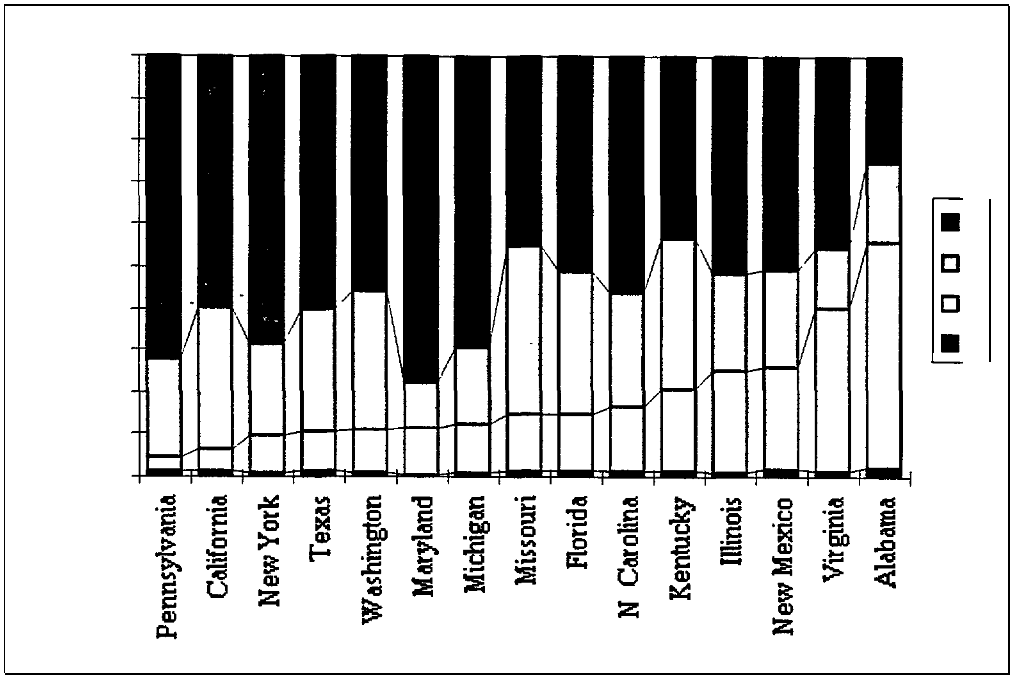

Figure 1.3-3 Distribution of The Proportions of KABC Injuries for Several GES States.

The reason this is a serious problem is that nearly one-quarter of all the "A" injuries coded in a three-year NASS-GES file come from a single state. Stated another way, 23% of the injuries come from about 3% of the PSUs. Because of the interaction of the injury variable with other factors, any time that "'A" injuries are used as a measure of crash severity, the result will be dominated by the characteristics of the crashes in one or two states.

Injury data (by KABCO category) are used in several places in the NHTSA report. The percentage of A injuries is used to indicate that Lead Vehicle Moving (LVM) crashes are more severe than are Lead Vehicle Stationary (LVS) crashes, with 4.6 percent A and K injuries for LVM and 3.0 percent for LVS. Eliminating the Alabama data from this computation yields values of 2.9 and 2.5 percent respectively a much smaller difference which is within the overlapping standard errors for the two values. It is appropriate to observe the difference, but it is a difference without much statistical justification. Of more concern' perhaps, is the estimation of the Fatal Crash Equivalent' FCE, in which the "A" injury accidents account for about one-third of the FCE.

1.4 SUMMARY

A study was conducted to determine the accuracy of the problem size assessment and benefits estimates based on using the FARS and the GES which indicated that the FARS data is accurate for estimating fatal accident numbers but the GES is somewhat inaccurate due to a number of factors. Some conclusions reached in this study regarding the GES areas follows:

- Comparing the police-reported accidents numbers in the GES versus FHWA studies indicate that the GES numbers are low by about 15%. This is due to a number of factors that affect the sampling system used in the GES.
- The number of non-police-reported accidents (not part of the GES) is significant. Their incidence is due to a variety of reasons including police department overload particularly in urban areas. Adding in accidents that are not reported to anyone (usually due to increased insurance rate fears) almost doubles the number of accidents in the GES database.
- The number of all low severity (TAD-l and TAD-2) accidents is under-reported particularly in urban areas, and the percentage of rear-end crashes that are of low severity is high. These factors may lead to au underestimate of rear-end crashes in the GES.
- Interpretation of injury scales from one jurisdiction to another leads to data bias. This is particularly true of some southern jurisdictions that tend to overestimate the number of "A" collisions.

Based on these results, the following adjustments to data obtained from the GES may be appropriate:

1. Increase the number of police-reported rear-end collisions by 15%.
2. A similar increase should be considered for the non-police-reported collisions. Further study is required to determine a more defensible number.
3. Decrease the number of “A” injuries for the southern region of the U.S. by 50% or decrease the total estimated “A” injuries in rear-end collisions by 25%.
4. Increase the number of rear-end collisions in urban areas by 40%.

SECTION 2
ACCIDENT FACTORS

In this section, the analysis of three accident data files, the 1989 NASS GES and state files from Michigan and Texas are presented. Data on a number of accident variables is presented which in some cases supplements the data presented in the NHTSA reports and is new data in other Cases. This type of analysis is useful in gaining an overall understanding of the rear-end collision avoidance problem and to assist in trade-offs that may be required in arriving at a specification. The analysis results are described in the following paragraphs. Each variable is tabulated and graphically illustrated.

2.1 1989 NASS GES

This section presents the results of the analysis of the 1989 NASS GES accident file data analysis. Shown below is a listing of the accident variable presented and the accompanying table and figure.

VARIABLE	TABLE & FIGURE NUMBER
Number of vehicles involved	2.1-1
Land use	2.1-2
Percent of the area that is rural	2.1-3
Relation to junction	2.1-4
Trafficway flow	2.1-5
Number of travel lanes	2.1-6
Roadway alignment	2.1-7
Roadway profile	2.1-8
Roadway surface condition	2.1-9
Traffic control device	2.1-10
Traffic device function	2.1-11
Light condition	2.1-12
Atmospheric condition	2.1-13
School bus involvement	2.1-14
Injury severity	2.1-15
Alcohol involvement	2.1-16

Table 2.1-1 and Figure 2. l-l show the number of rear-end collisions involving 2 to 7 vehicles and the number of vehicles involved in this type of collision. As expected, the overwhelming majority of rear-end collisions involve only two vehicles, and the data agrees with that presented in the NHTSA report.

Tables 2.1-2 and 2.1.3 and Figures 2.1-2 and 2.1-3 show the incidence of rear-end collisions versus land use in two different ways. Table and Figure 2.1-2 show that almost half of the accidents occur in areas with a population of <25,000 which agrees with the NHTSA report. Thirty percent or more of the accidents occur in urban areas. It doesn't seem likely that more collisions occur in less populated areas, and this perhaps confirms the point raised in Section 1 that rear-end collisions are under-reported in urban areas.

Table 2.1-4 and Figure 2.1-4 show the incidence of rear-end collisions is about equally split between accidents occurring around a junction or access and a non-junction area which agrees with the NHTSA report. This indicates that inputs to a countermeasures system relating to the presence of a junction or access would not be of great benefit.

Table 2.14 and Figure 2.1-5 show that the incidence of rear-end collisions is about equally divided (if the unknowns are equally assigned to the known categories) between non-divided, two-way roads and divided or one-way roads. Table 2.1-6 and Figure 2.1-6 show that rear-end collisions are also about equally divided between two-lane and multiple-lane roads. Again this indicates that trafficway flow and the number of lanes information would not benefit a countermeasures system.

Tables and Figures 2.1-7 and 2.1-8 show, as reported previously, that most rear-end collisions occur on straight, level roads. This statistic might lead one to believe that a straight-pointing, narrow-beam sensor would be adequate to alleviate the vast majority of rear-end collisions. However, this data may be misleading. Analysis of hard copy files revealed some coding problems probably related at least in part to the lack of definition of terms. It appears that while most rear-end collisions do occur on somewhat straight and level roads their incidence is over-represented. Another factor to consider is that while the accident might have occurred on a straight, level portion of the road a collision avoidance system, in order to be effective, might have to sense a potential collision on a curve or grade leading to the straight, level portion. The problem with false alarms arising on curves and grades also must be considered.

Table 2.1-9 and Figure 2.1-9 confirm NHTSA's finding that most rear-end collisions occur on dry roads. This is probably due to roads being dry more often than wet in most parts of the U.S. and to increased driver attention in wet conditions. The operation of a collision avoidance system is certainly a function of the roadway condition, and whether this data can be used to some benefit is yet to be determined. One possibility would be to accept reduced performance on wet roads, and this might be beneficial from a cost/benefit trade-off position. .

Tables and Figures 2.1-10 and 2.1-l 1 present some interesting information regarding traffic control devices which tends to confirm other findings that most rear-end collisions are due to driver inattention. (Drivers are likely more attentive in situations where they need to determine the status of traffic control devices.) Regarding the specification of a collision avoidance system, this data shows that aiding from traffic control devices won't help the situation much.

Table 2.1-12 and Figure 2.1-12 confirm NHTSA findings that most rear-end collisions occur in daylight conditions. This is most likely due to increased traffic. Despite these statistics, it would probably not be wise to specify a sensor that did not work in dark conditions.

Table 2.1-l 3 and Figure 2.1-l 3 show that weather is not a big contributor to rear-end collisions. Again, whether this fact can be used in countermeasures trade-offs has not been determined.

Tables 2.1-14 and Figure 2.1-14 show that there are very few rear-end collisions involving a school bus. On the other hand, looking at all accidents indicates that if there is an accident involving a school bus, 3 1% of these are rear-end.

Table 2.1-l 5 and Figure 2. l-l 5 confirm NHTSA findings that about two-thirds of rear-end collisions do not result in an injury and very few are fatal. This statistic should be weighed against the amount of property damage and lost time caused by rear-end collisions in determining the benefit of a rear-end collision avoidance system.

Table 2.1-16 and Figure 2.1-16 show that the GES indicates very little alcohol involvement in rear-end collisions. Examination of hard copy files have indicated that this figure is probably under-represented, but alcohol is still not a significant factor in rear-end collisions.

Table 2.1-1 Number of Rear-End Collisions vs. Number Of Vehicles Involved In Crash (GES 1989)

Number of Vehicles in accident	Number of rear-end collisions	Number of vehicles involved	Percent of Rear-end Collisions	Percent of all vehicles in Rear-end Collisions
2 vehicles involved	1369770	2799540	85.08%	78.37%
3 vehicles involved	197783	593349	12.29%	16.61%
4 vehicles involved	35245	140980	2.19%	3.95%
5 vehicles involved	5044	25220	0.31%	0.71%
6 vehicles involved	1452	8712	0.09%	0.24%
7 vehicles involved	615	4305	0.04%	0.12%
Total	1609909	3572106	100.0%	100.0%

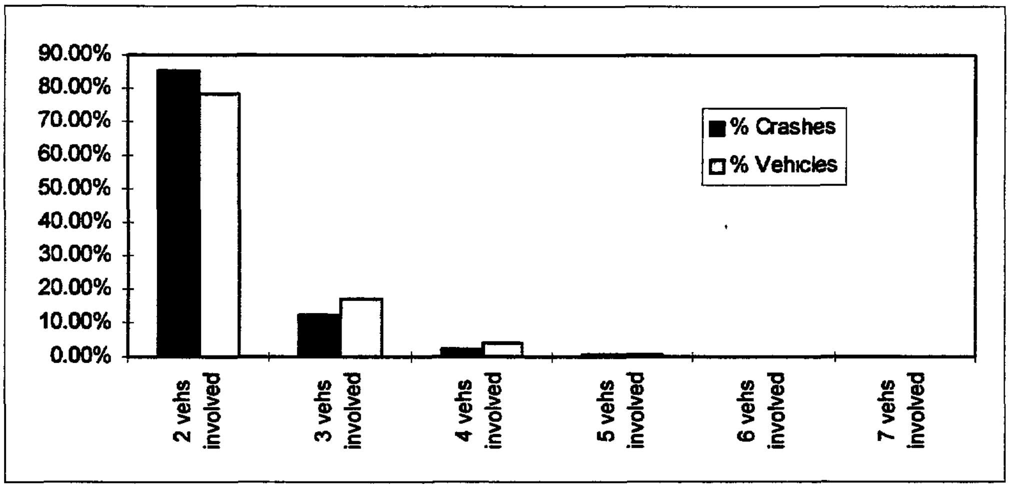

Figure 2.1-1 Percentage of Rear-End Collisions (and Percentage of Vehicles) Versus Number of Vehicles Involved in Crash (GES 1989)

Table 2.1-2 Number of Rear-End Collisions within an Area of the Designated Population (GES 1989)

Land use	Number of Rear-end Collisions	Percent of Rear-end Collisions
25,000-50,000	125772	7.81%
50,000-100000	218804	13.59%
pop 100,000+	470049	29.20%
Other area	735636	45.69%
unknown	59647	3.70%
TOTAL	1609908	100.00%

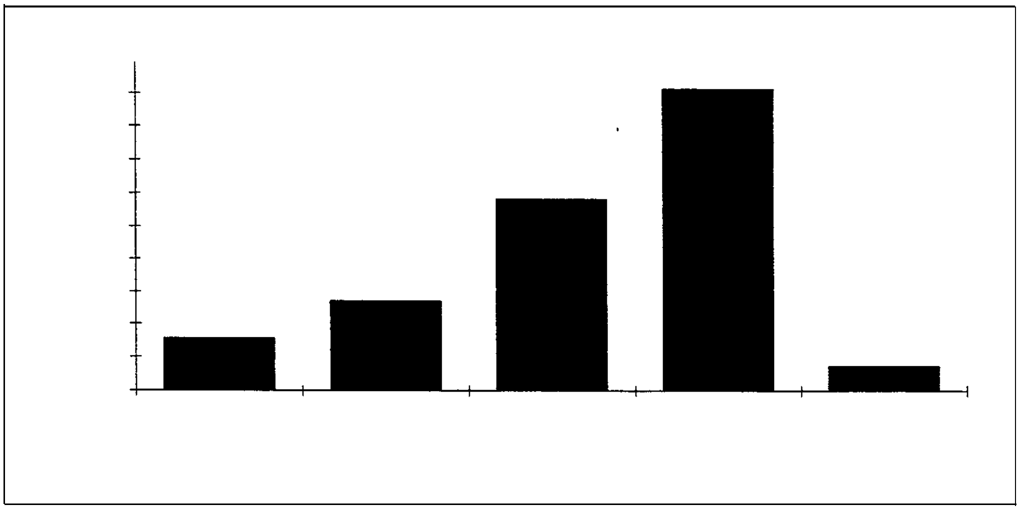

Figure 2.1-2 Percentage of Rear-End Collisions within an Area of the Designated Population (GES 1989)

Table 2.1-3 Number of Rear-End Collisions vs. Ruralness of the Area (GES 1989)

Percent rural	Number of Rear-end Collisions	Percentage of rear-end collisions
Urban	565303	35.13%
10% area rural	22343 1	13.88%
20% area rural	215104	13.37%
30% area rural	303873	18.88%
40% area rural	48405	3.01%
50% area rural	44382	2.76%
60% area rural	65540	4.07%
70% area rural	121144	7.53%
90% area rural	22199	1.38%
TOTAL	1609381	100.00%

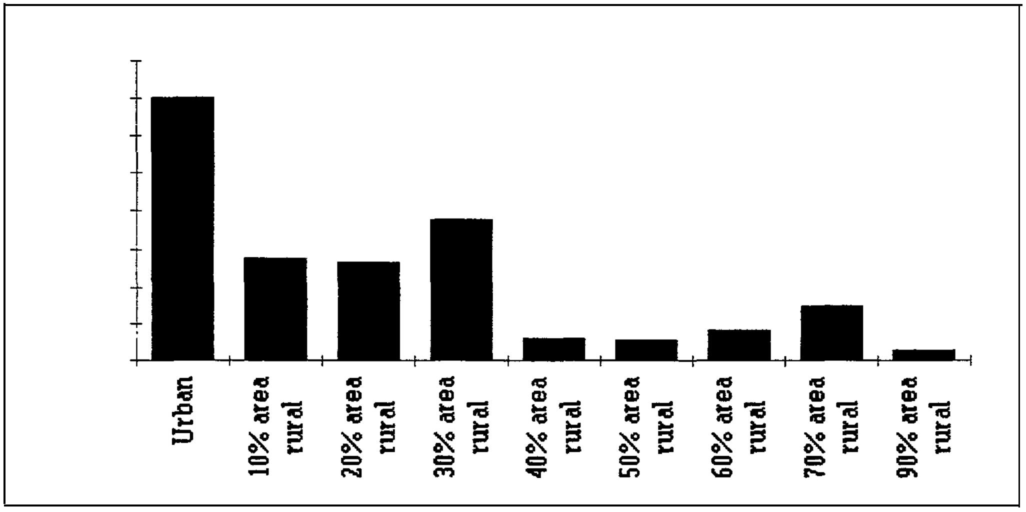

Figure 2.1-3 Percentage of Rear-End Collisions vs. Percent Rural for the Area (GES 1989)

Table 2.1-4 Number of Rear-End Collisions vs. Relation to Junction (GES 1989)

Relation to junction	Number of Rear-end Collisions	Percent of Rear-end Collisions
Non-junction	726616	45.13%
Intersection	240928	14.97%
Intersection Related	465805	28.93%
Interchange Area	9001	0.56%
Driveway, Alley	105574	6.56%
Enter/Exit Ramp	26737	1.66%
Rail Grade Cross	2100	0.13%
Other	12278	0.76%
Unknown	20868	1.30%
TOTAL	1609908	100.00%

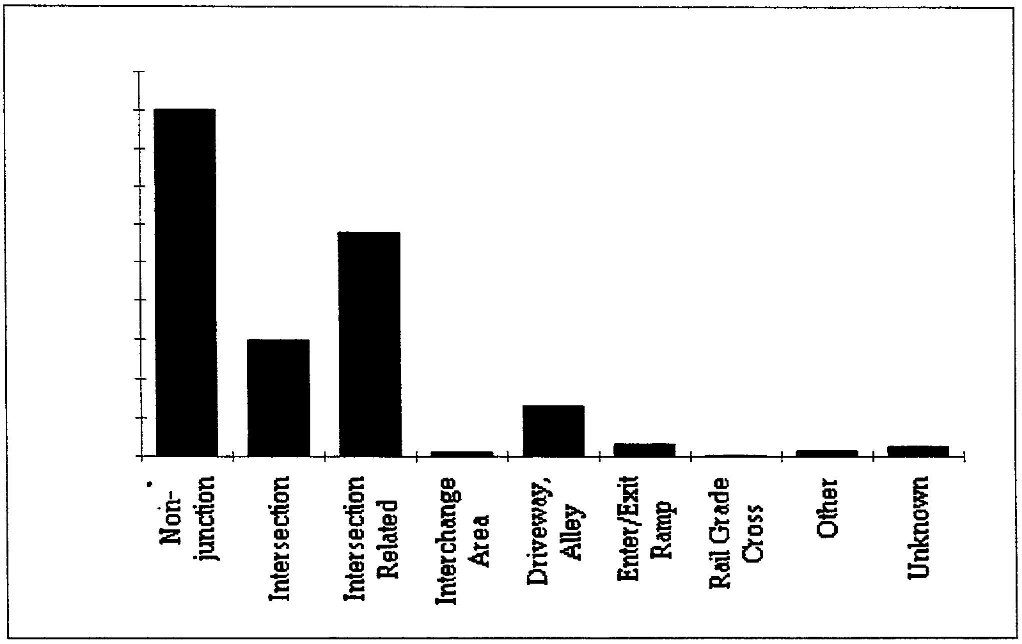

Figure 2.1-4 Percentage of Rear-End Collisions vs. Relation to Junction (GES 1989)

Table 2.1-5 Number of Rear-End Collisions vs. Trafficway Flow (GES 1989)

Trafficway Flow	**Number of Rear-end Collisions**	**Percent of Rear-end Collisions**
Not physically divided	**696489**	**43.26%**
Divided highway	39063 1	**24.26%**
1 -way trafficway	**70606**	**4.39%**
unknown	452183	**28.09%**
TOTAL	1609908	100.00%

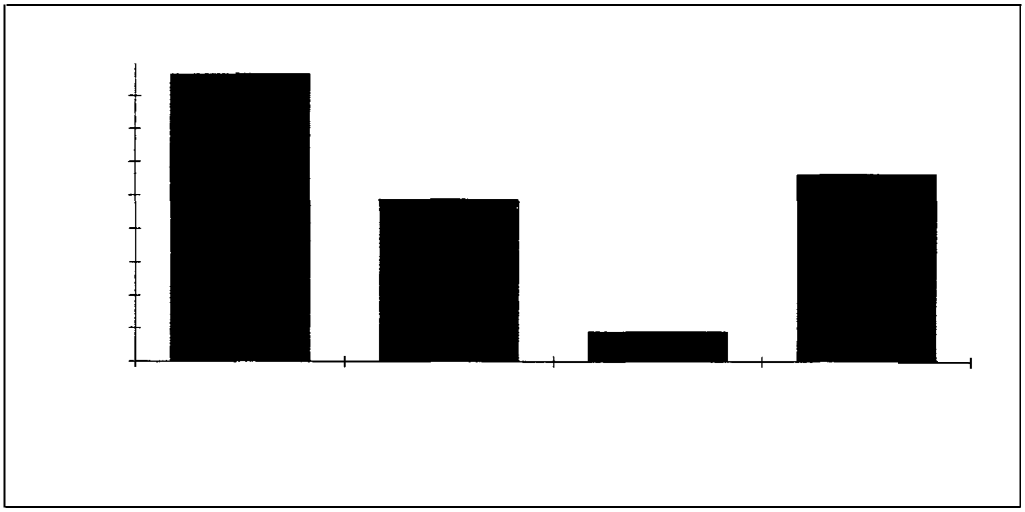

Figure 2.1-5 Percent of Rear-End Collisions by Trafiicway Flow (GES 1989)

Table 2.1-6 Proportion of Rear-End Collisions vs. Number of Travel Lanes (GES 1989)

Number of travel lanes	Number of Rear-end Collisions	Percent of Rear-end Collisions
One lane	46388	2.88%
Two lanes	576678	35.82%
Three lanes	185887	11.55%
Four lanes	275973	17.14%
Five lanes	108868	6.76%
Six lanes	21939	1.36%
Seven+ lanes	11945	0.74%
Unknown	382061	23.73%
TOTAL	1609908	100.00%

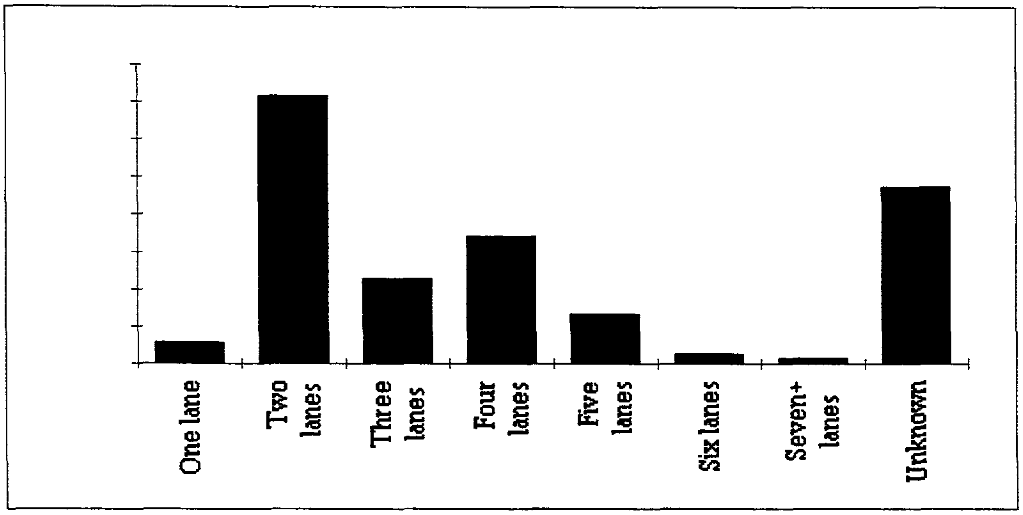

Figure 2.1-6 Percent of Rear-End Collisions by Number of Travel Lanes (GES 1989)

Table 2.1-7 Number of Rear-End Collisions by Roadway Alignment (GES 1989)

Roadway Alignment	Number of Rear-end Collisions	Percent of Rear-end Collisions
Straight	1467805	91.17%
Curve	95135	5.91%
unknown	46968	2.92%
TOTAL	1609908	100.00%

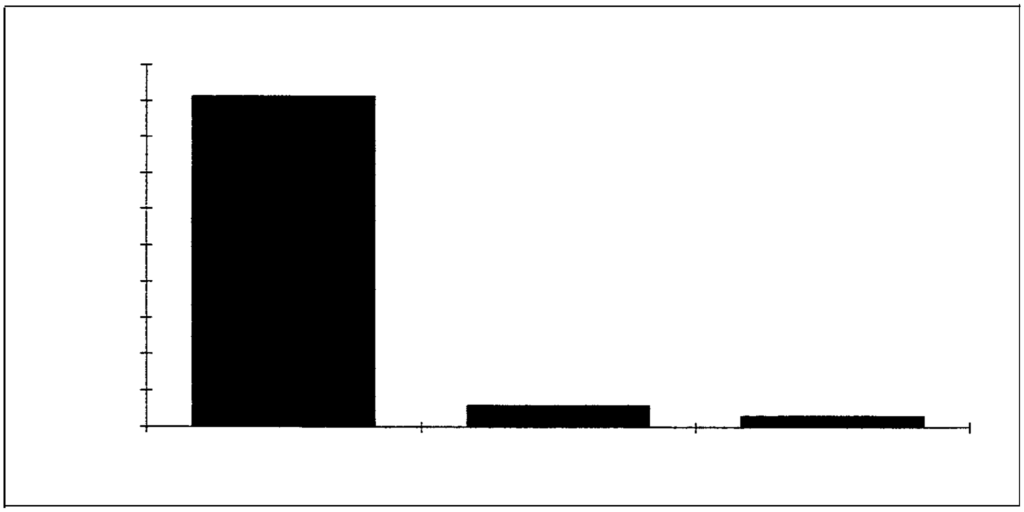

Figure 2.1-7 Percent of Rear-End Collisions by Roadway Alignment (GES 1989)

Table 2.1-8 Number of Rear-End Collisions by Roadway Profile (GES 1989)

Roadway profile	Number of Rear-end Collisions	Percent of Rear-end Collisions
Level	845684	52.53%
Grade	241076	14.97%
Hillcrest	20787	1.29%
Other	7331	0.46%
Unknown	495030	30.75%
TOTAL	1609908	100.00%

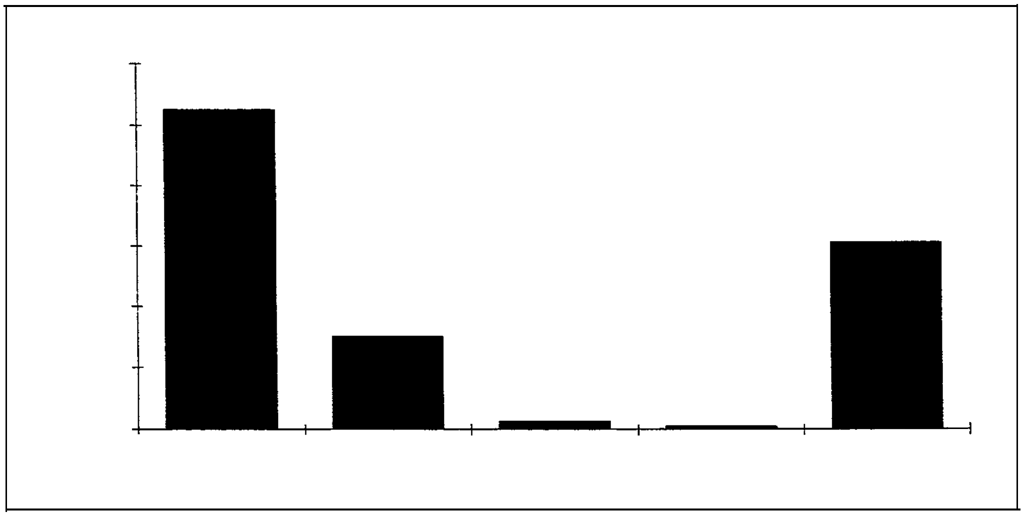

Figure 2.1-8 Percent of Rear-End Collisions by Roadway Profile (GES 1989)

Table 2.1-9 Number of Rear-End Collisions by Roadway Surface Condition (GES)

Roadway surface condition	Number of Rear-end Collisions	Percent of Rear-end Collisions
Dry	**1124599**	**69.85%**
Wet	**379400**	23.57%
Snow or slush	13628	0.85%
Ice	70252	4.36%
Sand, dirt, oil	1087	0.07%
Other	1368	0.08%
unknown	19573	1.22%
TOTAL	1609908	100.00%

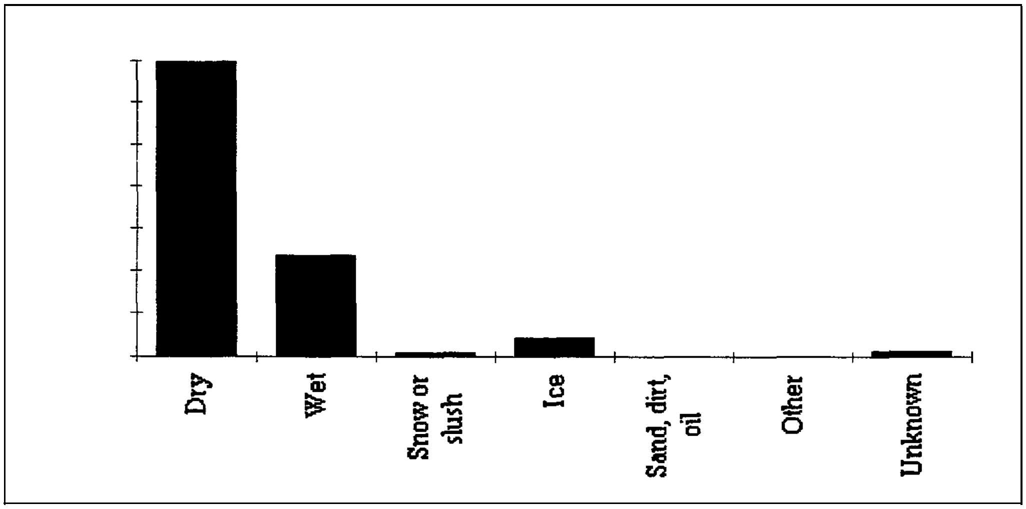

Figure 2.1-9 Percent of Rear-End Collisions by Roadway Surface Condition (GES 1989)

Table 2.1-10 Number of Rear-End Collisions vs. Traffic Control Device (GES 1989)

Traffic Control Device	Number of Rear-end Collisions	Percent of Rear-end Collisions
No controls	960451	59.66%
Stop & go sign	416241	25.85%
Flashing signal	5791	0.36%
Other traffic signal	7766	0.48%
Unknown traffic signal	1334	0.08%
Stop sign	96380	5.99%
Yield sign	31359	1.95%
School zone sign	387	0.02%
Warning sign	3610	0.22%
Other sign	801	0.05%
Officer, etc.	6583	0.41%
Active devices	2080	0.13%
Passive devices	1216	0.08%
Traffic control	19770	1.23%
Other traffic control	15046	0.93%
Unknown	41093	2.55%
TOTAL	1609908	100.00%

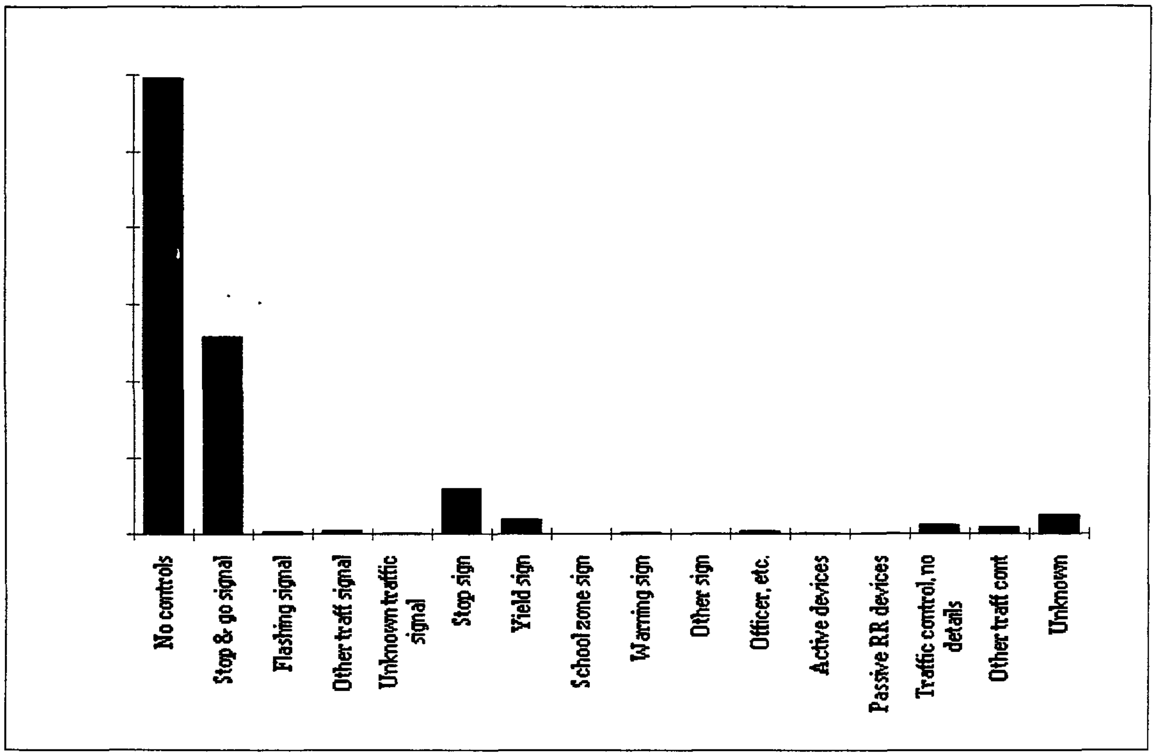

Figure 2.1-10 Percent of Rear-End Collisions vs. Traffic Control Device (GES 1989)

Table 2. l-l 1 Number of Rear-End Collisions vs. Traffic Device Function (GES 1989)

Traffic Device Function	Number of Rear-end Collisions	Percent of Rear-end Collisions
No controls	960451	59.66%
evice not functioning	582	0.04%
Functioning	584332	36.30%
Unknown	64542	4.01%
TOTAL	1609908	100.00%

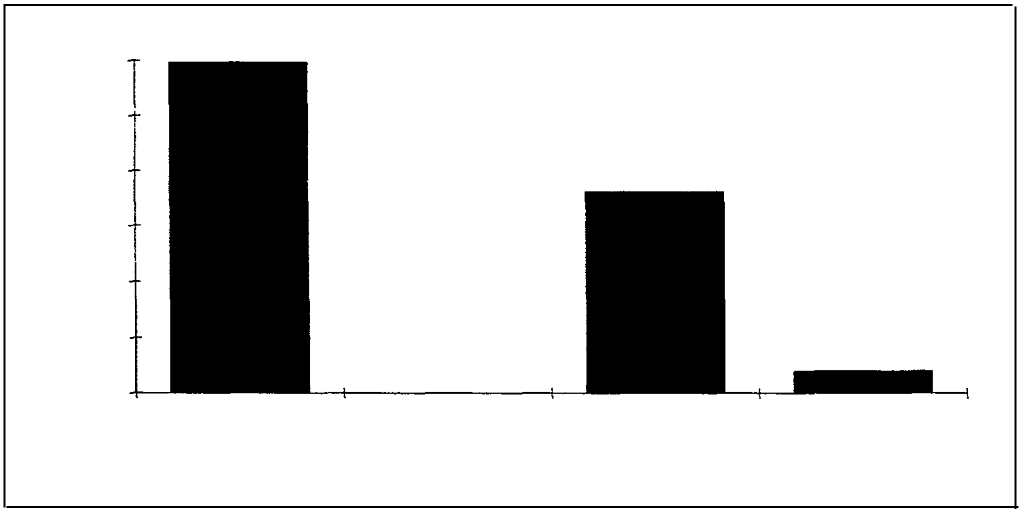

Figure 2.1-l 1 Percent of Rear-End Collisions vs. Traffic Control Device Function (GES 1989)

Table 2.1-12 Number of Rear-End Collisions vs. Light Condition (GES)

Light condition	Number of Rear-end Collisions	Percent of Rear-end Collisions
Daylight	1203502	74.76%
Dark	92182	5.73%
Dark, but lit	222153	13.80%
Dawn	11357	0.71%
Dusk	32379	2.01%
Dawn or Dusk	13647	0.85%
Unknown	34688	2.15%
TOTAL	1609908	100.00%

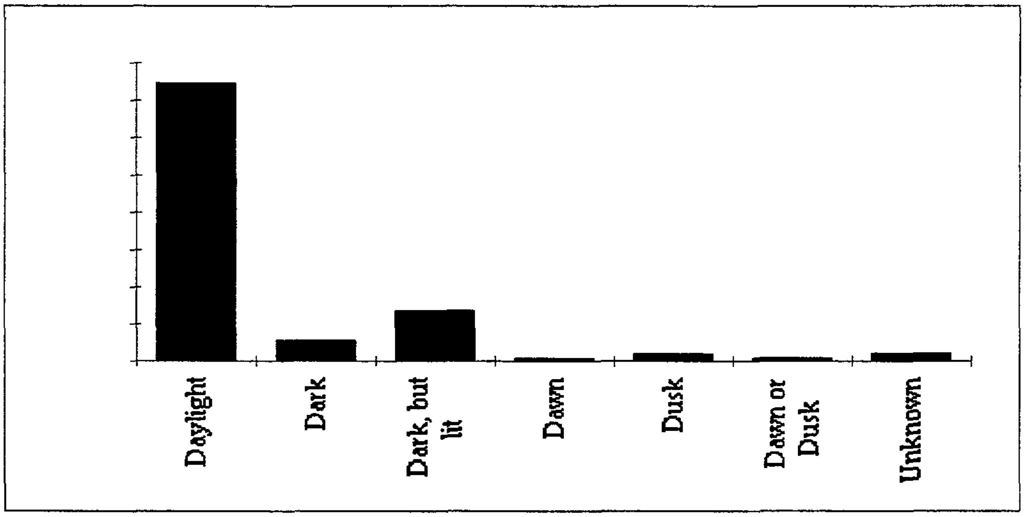

Figure 2.1-12 Percent of Rear-End Collisions vs. Light Condition (GES 1989)

Table 2.1-13 Number of Rear-End Collisions vs. Atmospheric Condition (GES 1989)

Atmospheric condition	Number of Rear-end Collisions	Percent of Rear-end Collisions
No adverse conditions	1249685	77.62%
Rain	263395	16.36%
Sleet	4805	0.30%
Snow	40419	2.51%
Fog	5343	0.33%
Other (smog, etc.)	11854	0.74%
Unknown	34406	2.14%
TOTAL	1609908	100.00%

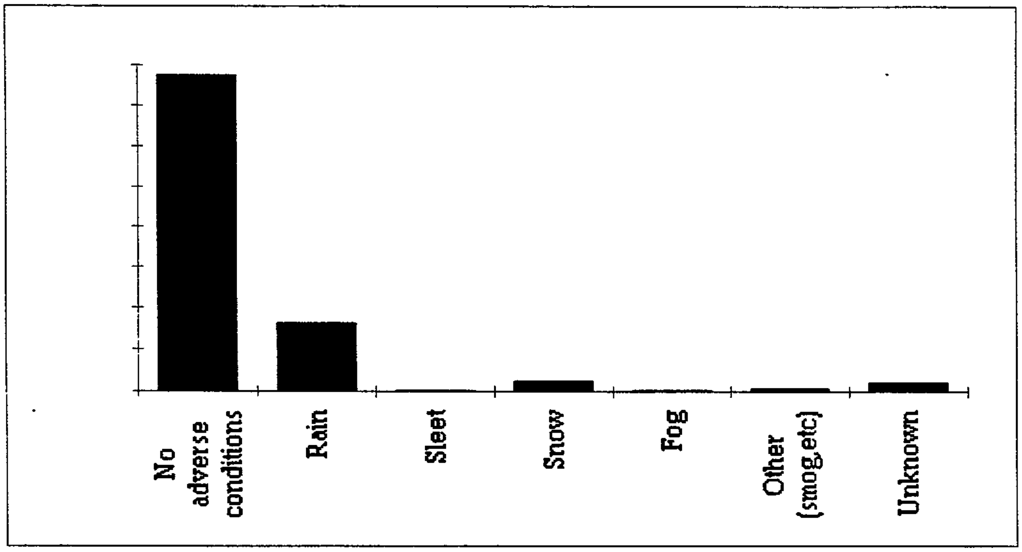

Figure 2.1-13 Percent of Rear-End Collisions vs. Atmospheric Condition (GES)

Table 2.1-14 Number of Rear-End Collisions vs. School Bus Relation to Accident (GES)

School bus involved	Number of Rear-end Collisions	Percent of Rear-end Collisions
No	1595174	99.29%
Yes	11427	0.71%
TOTAL	1606601	100.00%

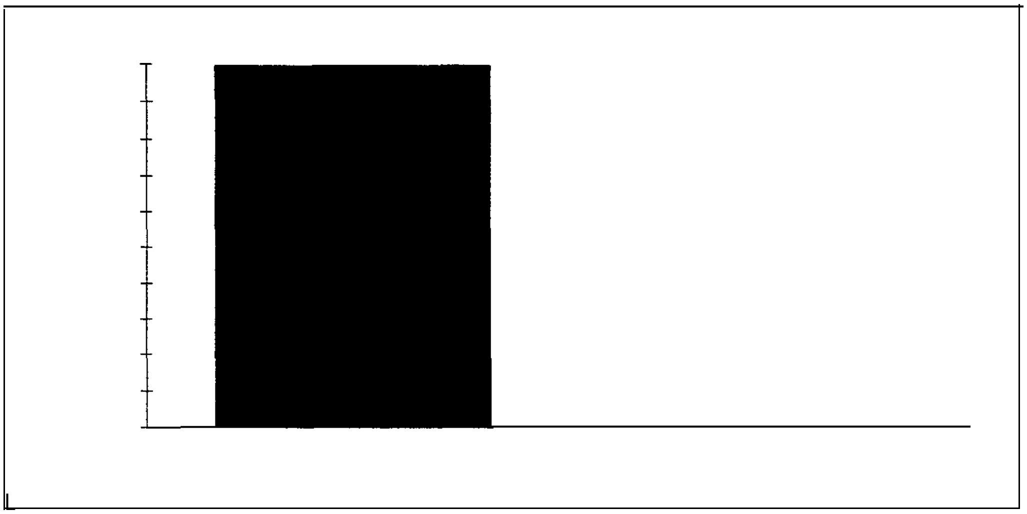

Figure 2.1-14 Percent of Rear-End Collisions vs. School Bus Relation to Accident (GES)

Table 2.1-15 Number of Rear-End Collisions vs. Maximum Injury Severity in Accident (GES)

Maximum Injury Severity	Number of Rear-end Collisions	Percent of Rear-end Collisions
No Injury	1072830	66.64%
Possible Injury	367987	22.86%
Non-incapacitating	102624	6.37%
Incapacitating	47100	2.93%
Fatal	1924	0.12%
Unknown Injury Severity	5980	0.37%
Died Prior	0	0.00%
No Person Coded	0	0.00%
Unknown	11464	0.71%
TOTAL	1609908	100.00%

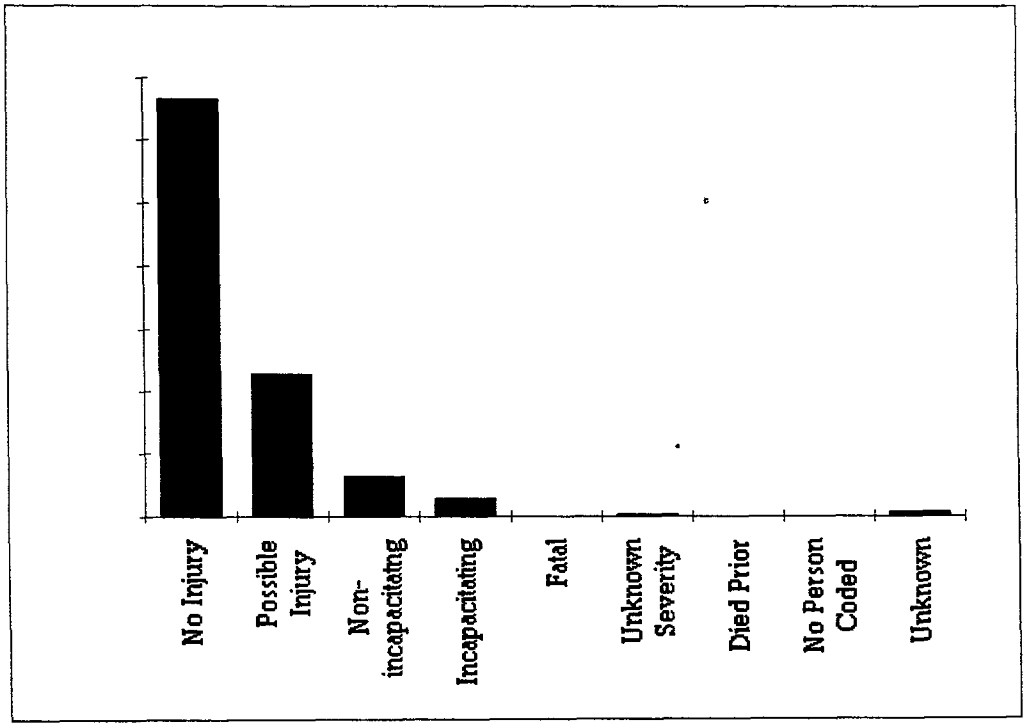

Figure 2.1-15 Percent of Rear-End Collisions vs. Maximum Injury Severity in Accident (GES 1989)

Table 2.1- 16 Number of Rear-End Collisions vs. Alcohol Involvement in Accident (GES 1989)

Alcohol In Accident	Number of Rear-end Collisions	Percent of Rear-end Collisions
Alcohol Involved	62354	3.87%
No Alcohol Involved	1534849	95.34%
No Person Coded	0	0.00%
Unknown	12705	0.79%
TOTAL	1609908	100.00%

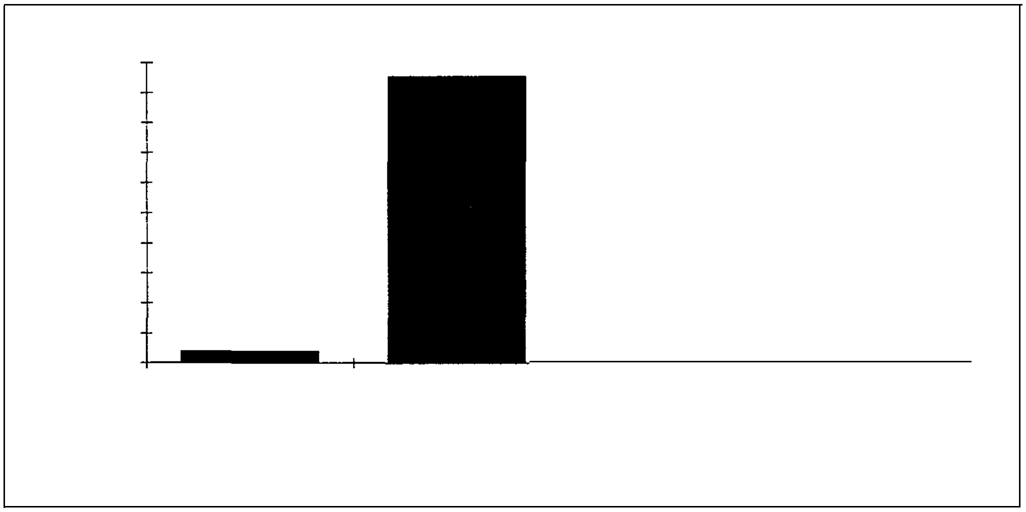

Figure 2.1-16 Percent of Rear-End Collisions vs. Alcohol Involvement in Accident (GES 1989)

2.2 1990 MICHIGAN STATE FILE

This section presents data gathered from an analysis of accident data file from Michigan in 1990. Some of the variables for which data are presented are the same as presented in section 2.1 for the NASS GES for comparative purposes. Some of the data presented is not available in the GES. Note that this analysis was done using census files, and statistical test are inappropriate. The following is a list of variables considered and the associated table and figure number.

VARIABLE	TABLE & FIGURE NUMBER
Month	**2.2-1**
Highway area type (junction related)	2.2-2
Road curvature	2.2-3
Road surface condition	2.2-4
Type of traffic control	2.2-5
Construction zone	2.2-6
Weather	2.2-7
Light	2.2-8
Population class	2.2-9
Accident circumstance	2.2-10
Traffic unit mix (type vehicles)	2.2-l 1
Alcohol involvement	2.2-12
Injury severity	2.2-13

Rear-end collisions are defined in the Michigan police files for two-vehicle crashes only. As a result, the percentage of rear-end collisions is lower than the GES averaging about 19% of all crashes.

The following is a summary of the data analysis results from Michigan that substantially agree with the data in the GES.

- Month - no effect
- Road curvature - most collisions on a straight roads.
- Road surface condition - most collisions on dry roads.
- Type of traffic control - no effect.

- Weather - bad weather no effect.
- Light - most accidents in daylight.
- Traffic unit mix - most accidents are car-car with car-truck second.
- Alcohol involvement - no effect.
- Injury severity - most rear-end collisions are non-injury.

For the following two items there was some disagreement.

- Highway area type - Michigan data shows a high incidence of intersection related accidents (67%) The GES indicated a lower figure, but this is probably due to coding variations.
- Population class - Michigan data indicated that about 17% of the rear-end collisions occurred in areas with a population of <25,000 versus almost 50% in GES. The reason for the discrepancy is unknown.

The following information is not coded in the GES.

- Construction zone - The presence of a construction zone proved to have no effect in the Michigan data.
- Accident circumstance - The Michigan data indicated that following too close was the cause of about 80% of all rear-end collisions. The hard copy file analysis of CDS data indicated that inattention or inattention related situations were the major cause. This is probably because "following too close" is a common violation coding used by the police when issuing citations.

Table 2.2-1 Number of Rear-End Collisions vs. Month of the Year (Michigan 1990)

Month	Number of Rear-End Collisions	Percent of Rear-end Collisions
January	5301	7.24%
February	7231	9.88%
March	5114	6.99%
April	5400	7.38%
May	6575	8.99%
June	6357	8.69%
July	5975	8.16%
August	5970	8.16%
September	6037	8.25%
October	6730	9.20%
November	5853	8.00%
December	6643	9.08%
TOTAL	73177	100.00%

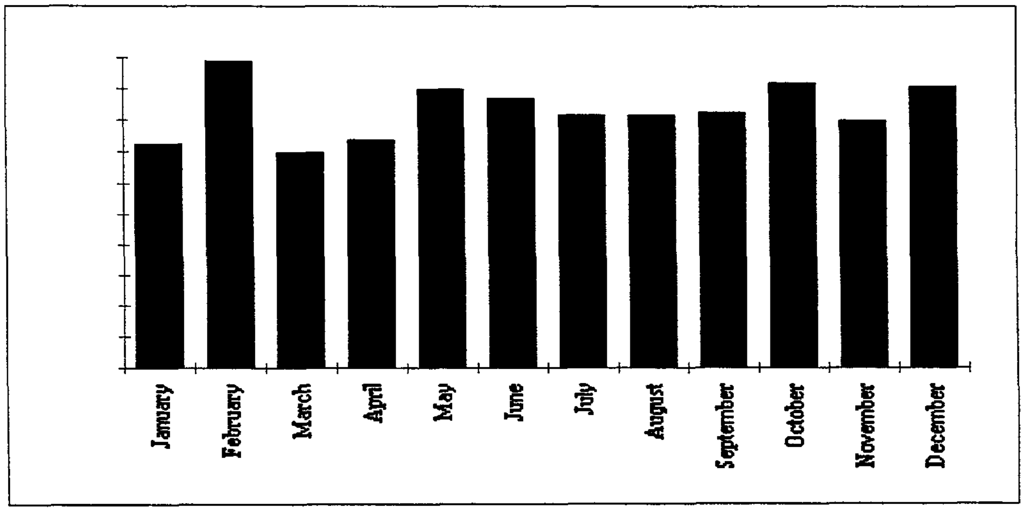

Figure 2.2-1 Percent of Rear-End Collisions by Month of the Year (Michigan 1990)

Table 2.2-2 Number of Rear-End Collisions vs. Highway Area Type (Michigan 1990)

Highway area type	Number of Rear-end Collisions	Percent of Rear-end Collisions
Interchange	**4621**	**6.32%**
Intersection	49182	67.21%
Other area	19362	**26.46%**
TOTAL	73177	100.00%

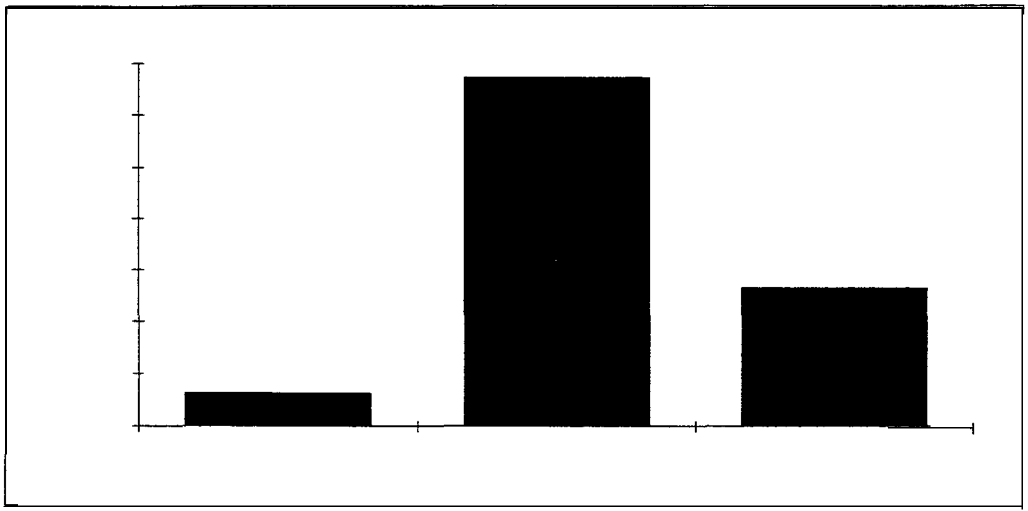

Figure 2.2-2 Percent of Rear-End Collisions vs. Highway Area Type (Michigan 1990)

Table 2.2-3 Number of Rear-End Collisions vs. Road Alignment (Michigan 1990)

Road alignment	Number of Rear-end Collisions	Percent of Rear-end Collisions
Straight	71151	97.40%
Curve	1688	2.31%
Transition	213	0.29%
TOTAL	73052	100.00%

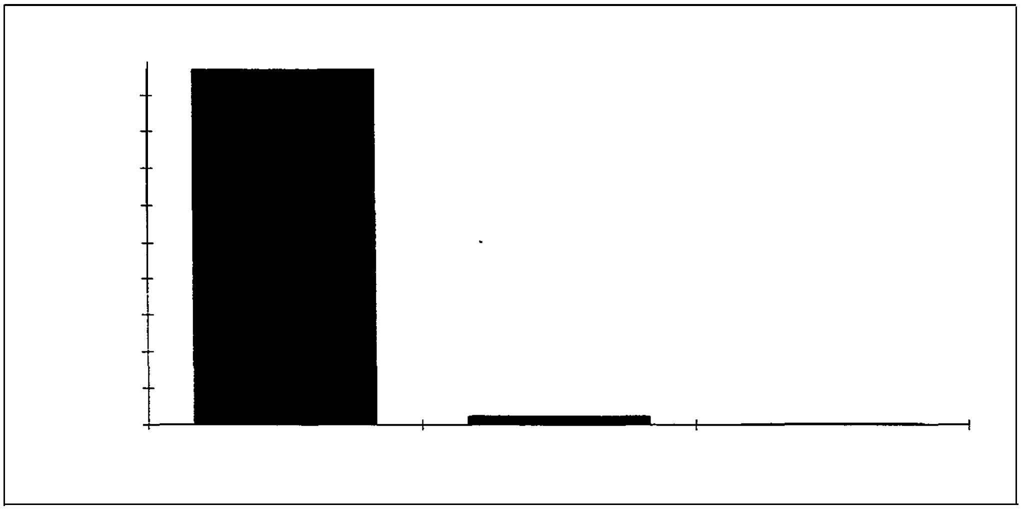

Figure 2.2-3 Percent of Rear-End Collisions vs. Road Alignment (Michigan 1990)

Table 2.2-4 Number of Rear-End Collisions vs. Road Surface Condition (Michigan 1990)

Road Surface Condition	Number of Rear-end Collisions	Percent of Rear-end Collisions
Dry	45519	62.31%
Wet	19866	27.20%
Snowy/icy	7732	10.59%
TOTAL	73048	100.00%

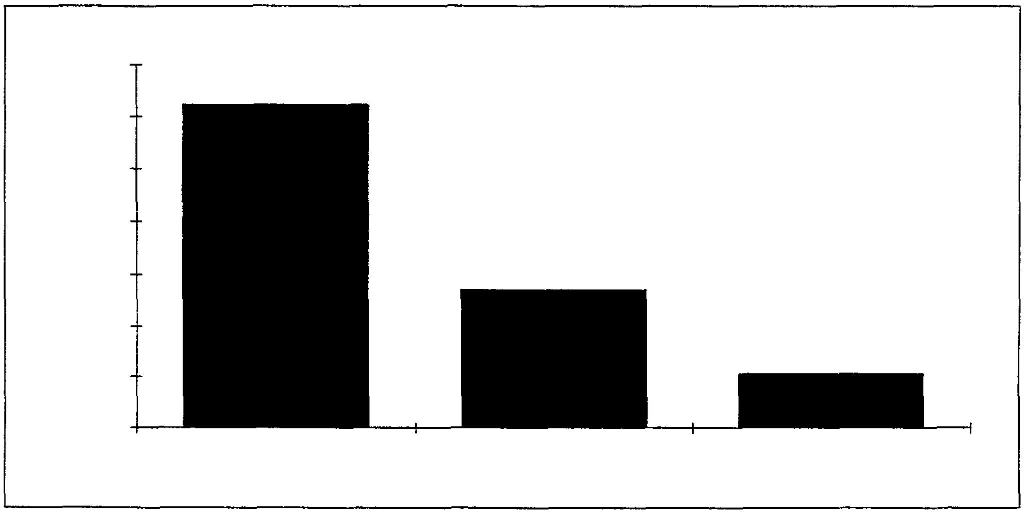

Figure 2.2-4 Percent of Rear-End Collisions vs. Road Surface Condition (Michigan 1990)

Table 2.2-5 Number of Rear-End Collisions vs. Type of Traffic Control (Michigan 1990)

Traffic Control Type	Number of Rear-end Collisions	Percent of Rear-end Collisions
None	31172	42.68%
Stop sign	14223	19.48%
Stop & go signal	25643	35.11%
Traffic regulator	68	0.09%
Flasher	1059	1.45%
Yield sign	468	0.64%
School zone	2	0.00%
No passing zone	393	0.54%
Warning sign	106	0.15%
TOTAL	73028	100.00%

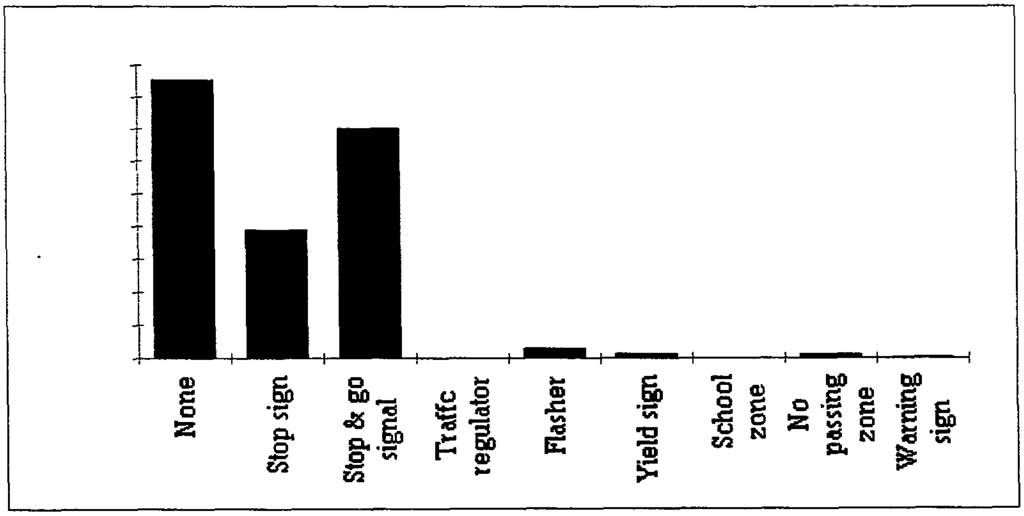

Figure 2.2-5 Percent of Rear-End Collisions vs. Type of Traffic Control (Michigan 1990)

Table 2.2-6 Number of Rear-End Collisions vs. Presence of Construction Zone (Michigan 1990)

Construction Zone?	Number of Rear-end Collisions	Percent of Rear-end Collisions
Non construction zone	71315	97.60%
Construction zone	1756	2.40%
TOTAL	73071	100.00%

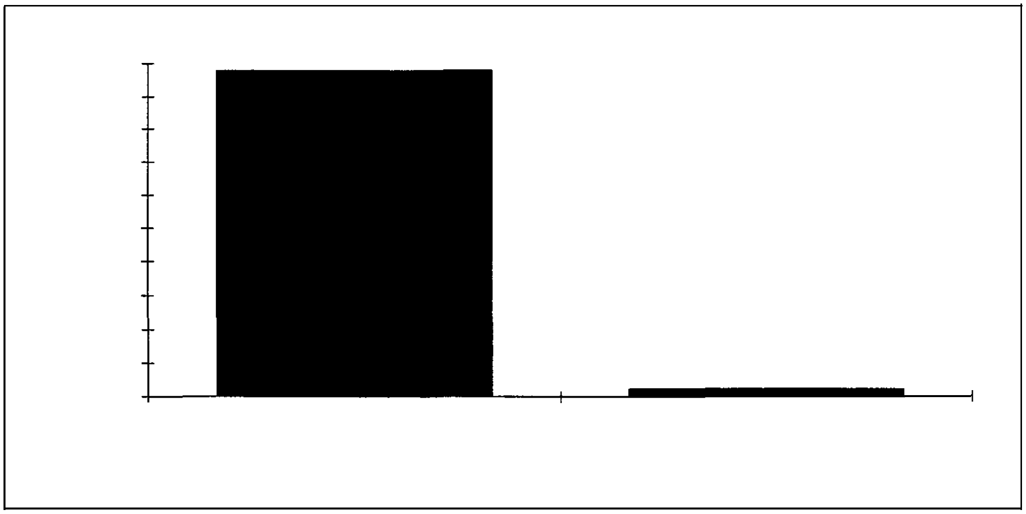

Figure 2.2-6 Percent of Rear-End Collisions vs. Presence of Construction Zone (Michigan 1990)

Table 2.2-7 Number of Rear-End Collisions vs. Weather Condition (Michigan 1990)

Weather Condition	Number of Rear-end Collisions	Percent of Rear-end Collisions
'Clear/cloudy	54861	75.15%
Fog	658	0.90%
Raining	12720	17.42%
Snowing	4908	6.72%
TOTAL	73004	100.00%

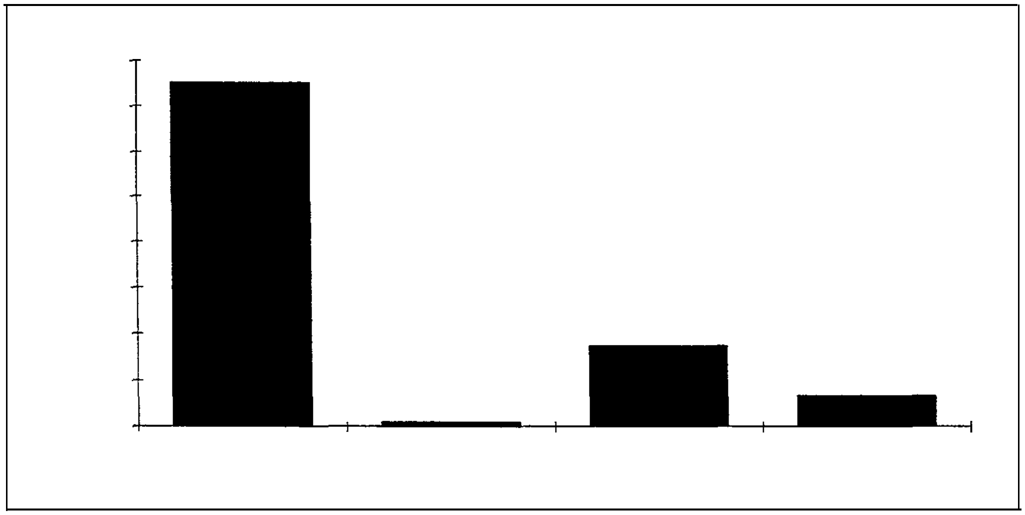

Figure 2.2-7 Percent of Rear-End Collisions Vs Weather Condition (Michigan 1990)

Table 2.2-8 Number of Rear-End Collisions vs. Light Condition (Michigan 1990)

Light Condition	Mean	N
Daylight	55179	75.65%
Dawn or dusk	3178	4.36%
Day-street light	6844	9.38%
Dark-no street light	7807	10.70%
TOTAL	72939	100.00%

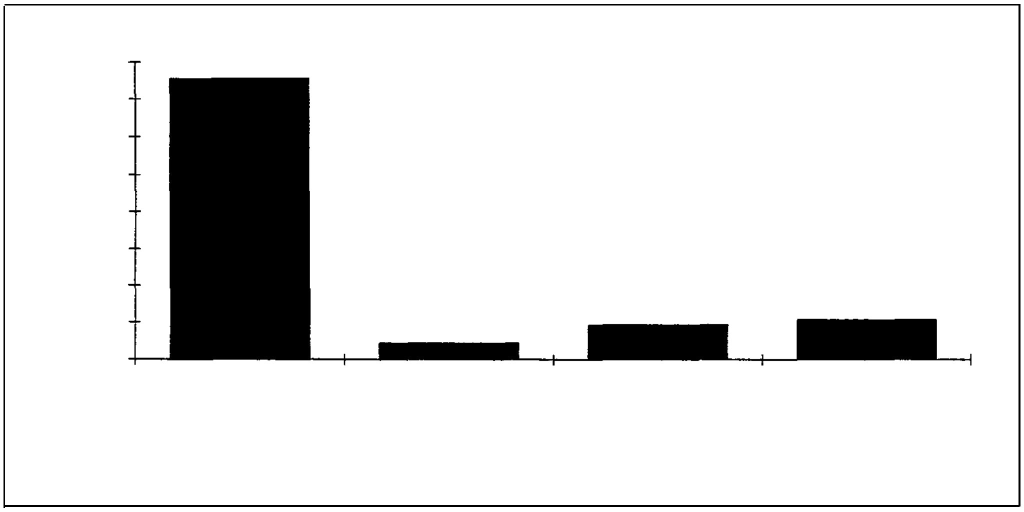

Figure 2.2-8 Percent of Rear-End Collisions vs. Light Condition (Michigan 1990)

Table 2.2-9 Number of Rear-End Collisions vs. Population Class (Michigan 1990)

Population class	Number of Rear-end Collisions	Percent of Rear-end Collisions
Township	20475	27.98%
Less than 1000	364	0.50%
1000 to 2500	1246	1.70%
2500 to 5000	2160	2.95%
5000 to 10000	2664	3.64%
10000 to 25000	**6027**	**8.24%**
25000 to 50000	**9361**	**12.79%**
50000 to 100000	**11773**	**16.09%**
100000 to 250000	9033	12.34%
More than 250000	10075	13.77%
TOTAL	73177	100.00%

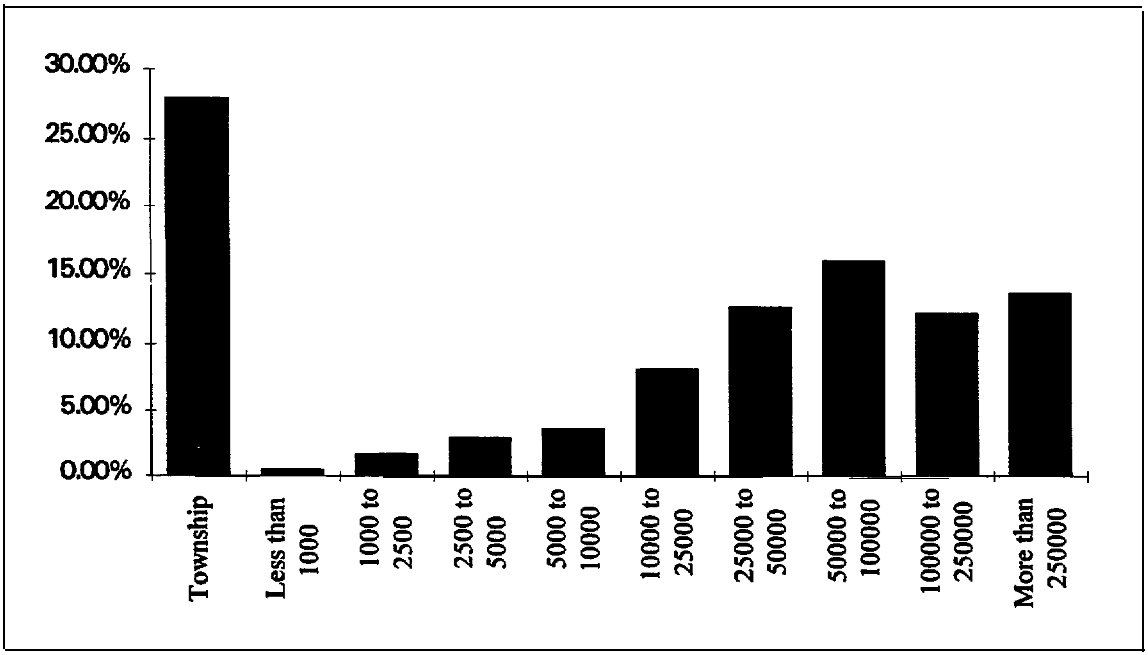

Figure 2.2-9 Percent of Rear-End Collisions vs. Population Class (Michigan 1990)

Table 2.2-10 Number of Rear-End Collisions vs. Accident Circumstance (Michigan 1990)

Circumstance	Number of Rear-end Collisions	Percent of Rear-end Collisions
Speed too fast	3806	5.30%
Failed to yield	1206	1.68%
Left of center	4626	6.44%
Follow too close	57447	79.99%
Improper turn	1249	1.74%
Inattention or illness	26	0.04%
Other Improper Driving	3233	4.50%
Was drinking	131	0.18%
Pedestrian error	0	0.00%
Defective tires	10	0.01%
Other defect	68	0.09%
Road defect	15	0.02%
TOTAL	71817	100.00%

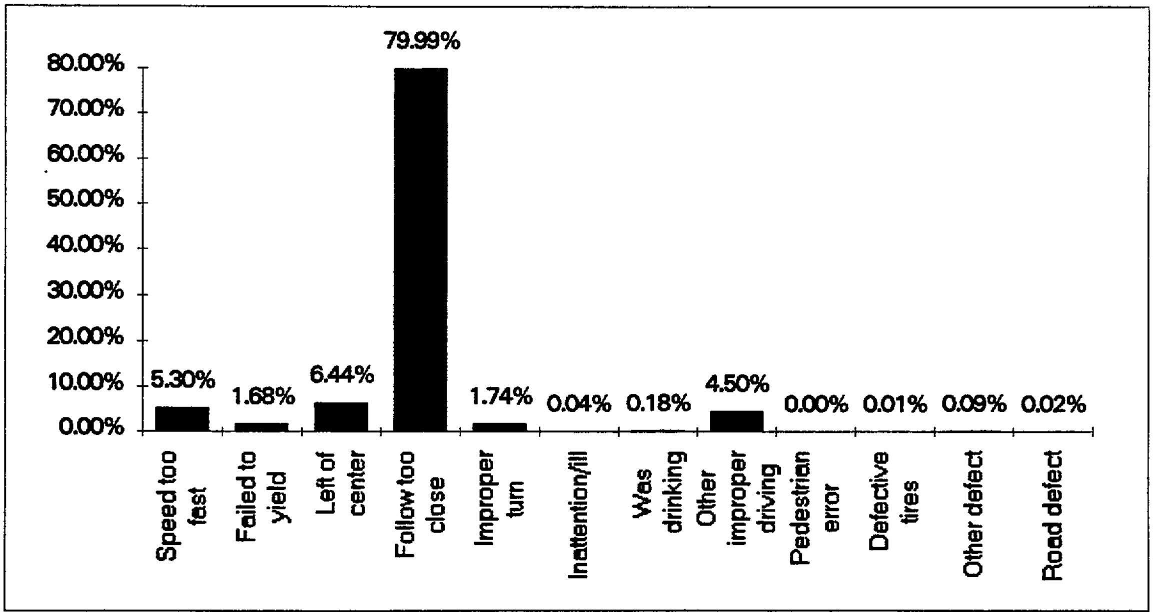

Figure 2.2-10 Percent of Rear-End Collisions vs. Accident Circumstance (Michigan 1990)

Table 2.2-l 1 Number of Rear-End Collisions vs. Traffic Unit Mix (Michigan 1990)

Traffic Unit Mix	Number of Rear-end Collisions	Percent of Rear-end Collisions
Single Traffic Unit	0	0.00%
Car-car	44588	66.66%
Car-truck	18410	27.52%
Car-motorcycle	308	0.46%
Car-other	1232	1.84%
Car-pedal cyclist	0	0.00%
Truck-truck	2031	3.04%
Truck-motorcycle	62	0.09%
Truck-other	224	0.34%
Truck-pedestrian/cyclist	0	0.00%
Motorcycle-motorcycle	15	0.02%
Motorcycle-other	8	0.01%
Motorcycle-pedestrian, cyclist	0	0.00%
Other-other	35	0.05%
Other-pedestrian, cyclist	0	0.00%
3 or more TUs	0	0.00%
TOTAL	66892	100.00%

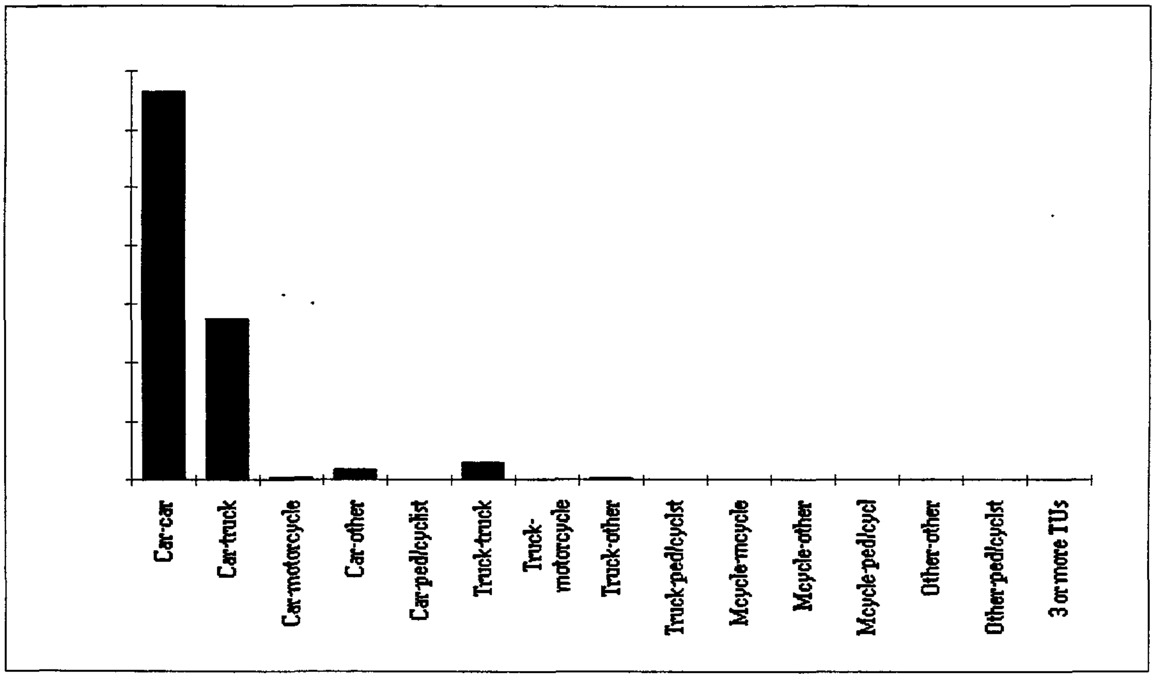

Figure 2.2-11 Percent of Rear-End Collisions vs. Traffic Unit Mix (Michigan 1990)

Table 2.2-12 Number of Rear-End Collisions vs. Drinking in Accident (Michigan 1990)

Drinking in Accident	Number of Rear-end Collisions	Percent of Rear-end Collisions
Drinking	4172	5.81%
No drinking	**67698**	94.19%
TOTAL	**72020**	100.00%

Figure 2.2-12 Percent of Rear-End Collisions Vs Drinking in Accident (Michigan 1990)

Table 2.2- 13 Number of Rear-End Collisions vs. Severity of Accident (Michigan 1990)

Accident Severity	Number of Rear-end Collisions	Percent of Rear-end Collisions
Fatal	36	0.05%
Injury	18229	24.91%
Prop damage	55066	75.25%
TOTAL	73177	100.00%

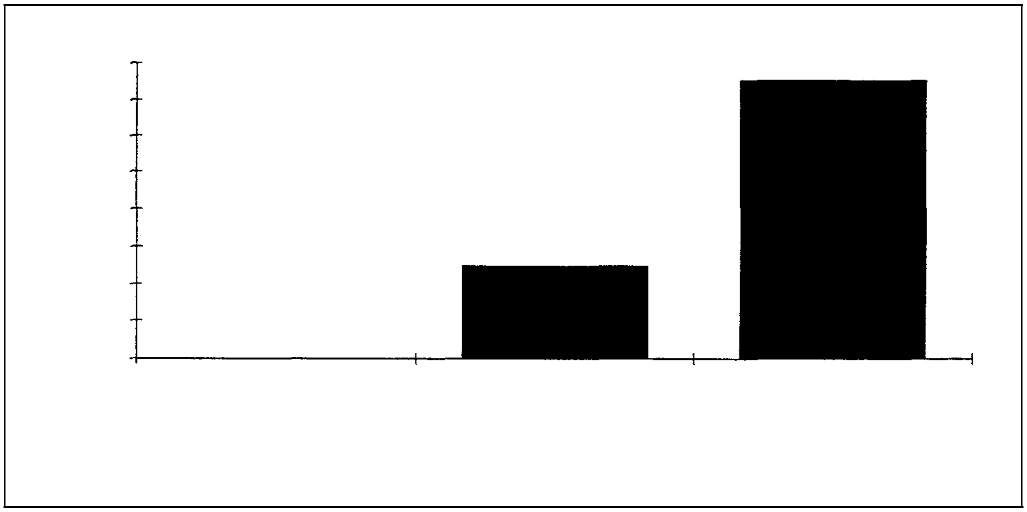

Figure 2.2-13 Percent of Rear-End Collisions vs. Accident Severity (Worst Injury in Accident) (Michigan 1990)

2.3 1990 TEXAS STATE DATA

This section presents data gathered from an analysis of state accident data files from Texas in 1990. Some of the variables for which data are presented are the same as presented in Section 2.1 for the NASS GES for comparative purposes. Some of the data presented is not available in the GES. Texas does not have a single level of any variable to indicate a rear-end collision. A "vehicle movements" variable has about 50 levels five of which may be characterized as a rear-end collision. These vehicle movements variables are as follows:

20. Two vehicles going same direction; both going straight, rear-end
22. Two vehicles going same direction: vehicle 1 going straight, vehicle 2 stopped
23. Two vehicles going same direction: vehicle 1 going straight, vehicle 2 turning light
24. . Two vehicles going same direction: vehicle 1 going straight, vehicle 2 turning left
40. Two vehicles - other movements: vehicle 1 going straight, vehicle 2 parking

About 28% of all reported accidents in Texas are rear-end collisions based on the above coding. This is somewhat higher than the GES indicates. The following is a list of the variables analyzed and their location.

VARIABLE	TABLE & FIGURE NUMBER
Month	2.3-1
Population class	2.3-2
Road curvature	2.3-3
Road alignment	2.3-4
Road surface condition	2.3-5
Road pavement condition	2.3-6
Traffic control	2.3-7
Intersection related	2.3-8
Number of entering roads	2.3-9
Other roadway features	2.3-10 and 2.3-11
Weather condition	2.3-12
Light condition	2.3-13
Traffic unit mix	2.3-14
Contributing factor	2.3-15

Injury severity	2.3-16

The following is a summary of the Texas data that substantially agrees with the GES data:

- Month - no effect.
- Road curvature - most rear-end collisions occur on straight roads.
- Road alignment 1 most rear-end collisions occur on level roads.
- Road surface condition - most rear-end collisions occur on dry roads.
- Intersection related - about equally split between intersection and not.
- Weather condition - no effect from bad weather.
- Light condition - most rear-end collisions occur in daylight.
- Traffic unit mix - most accidents are car-car and car-truck.
- Injury severity - most rear-end collisions do not involve an injury.

For the following items there was some disagreement:

- Population class - The GES indicated that about 45% of rear-end collisions occurred in populations of <25,000 while the Texas data has 45% in populations of 250,000 or more. This may be due the sites sampled in the GES or factors mentioned previously regarding under-reporting of rear-end collisions in some urban areas.
- Traffic control - This variable is different in the Texas system; it includes a center divider category and 62% of the rear-end collisions were coded here.

The following items are not coded in the GES:

- Road pavement condition - The Texas data indicates that this is not a factor as 88% of the rear-end collisions were on roads with no defects.
- Other roadway features - This is a long list of possible features none of which appear to have any effect.
- Contributing factor - This is a long list of possible causal factors with avoiding a stopped vehicle predominating.

Table 2.3-l Number of Rear-End Collisions vs. Month of the Year (Texas 1990)

Month of Year	Number of Rear-end Collisions	Percent of Rear-end Collisions
January	8368	7.75%
February	8298	7.69%
March	9686	8.97%
April	9257	8.58%
May	9576	8.87%
June	9190	8.51%
July	8987	8.33%
August	9417	8.72%
September	8783	8.14%
October	9140	8.47%
November	8741	8.10%
December	8681	8.04%
TOTAL	107949	100.00%

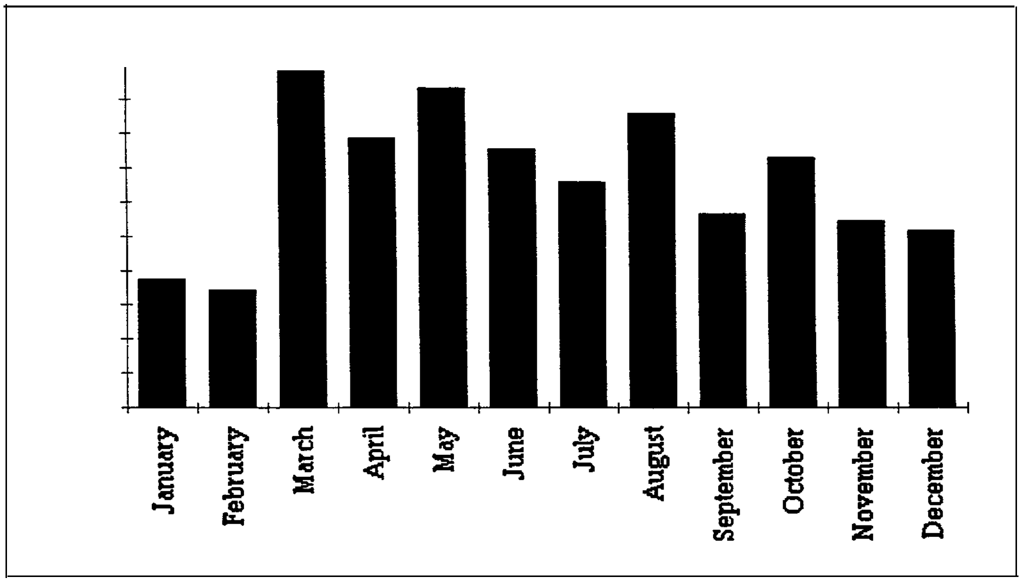

Figure 2.3-l Percent of Rear-End Collisions vs. Month of the Year (Texas 1990)

Table 2.3-2 Number of Rear-End Collisions vs. Population Class (Texas 1990)

Population Class	Number of Rear-end Collisions	Percent of Rear-end Collisions
Rural	11619	10.76%
Less than 2500	3421	3.17%
2500 to 5000	2971	2.75%
5000 to 10000	3532	3.27%
10000 to 25000	11132	10.3 1%
25000 to 50000	6234	5.77%
50000 to 100000	11119	10.30%
100000 to 250000	9949	9.22%
More than 250000	48055	44.52%
TOTAL	107949	100.00%

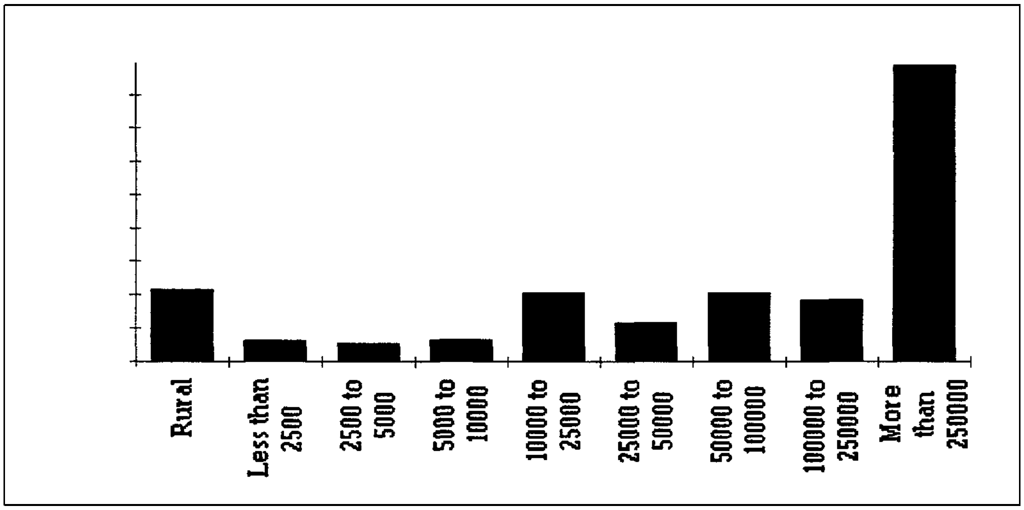

Figure 2.3-2 Percent of Rear-End Collisions vs. Population Class (Texas 1990)

Table 2.3-3 Number of Rear-End Collisions vs. Road Curvature (Texas 1990)

Curvature	Number of rear-end collisions	Percent of Rear-end Collisions
Straight	33071	85.18%
0.1- 1.9 degrees	2705	6.97%
2.0- 3.9 degrees	1755	4.52%
4.0- 5.9 degrees	595	1.53%
6.0- 7.9 degrees	232	0.60%
8.0- 9.9 degrees	98	0.25%
10.0-l 1.9 degrees	84	0.22%
12.0-13.9 degrees	19	0.05%
14.0-15.9 degrees	22	0.06%
16.0-l 7.9 degrees	2	0.01%
18.0+ degrees	144	0.37%
TOTAL	38825	100.00%

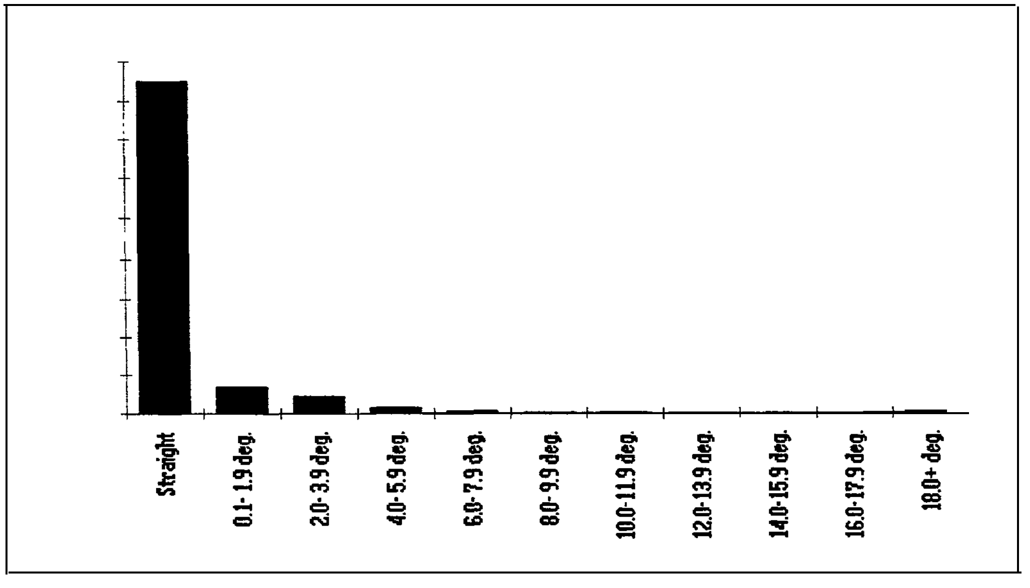

Figure 2.3-3 Percent of Rear-End Collisions by Degree of Curvature of Road (Texas 1990)

Table 2.3-4 Proportion of Rear-End Collisions by Road Alignment (Texas 1990)

Alignment	Number of Rear-end Collisions	Percent of Rear-end Collisions
Straight - level	106573	98.73%
Straight - grade	239	0.22%
Straight-hillcrest	249	0.23%
Curve - level	1116	1.03%
Curve - grade	18	0.02%
Curve-hillcrest	8	0.01%
TOTAL	107949	100.00%

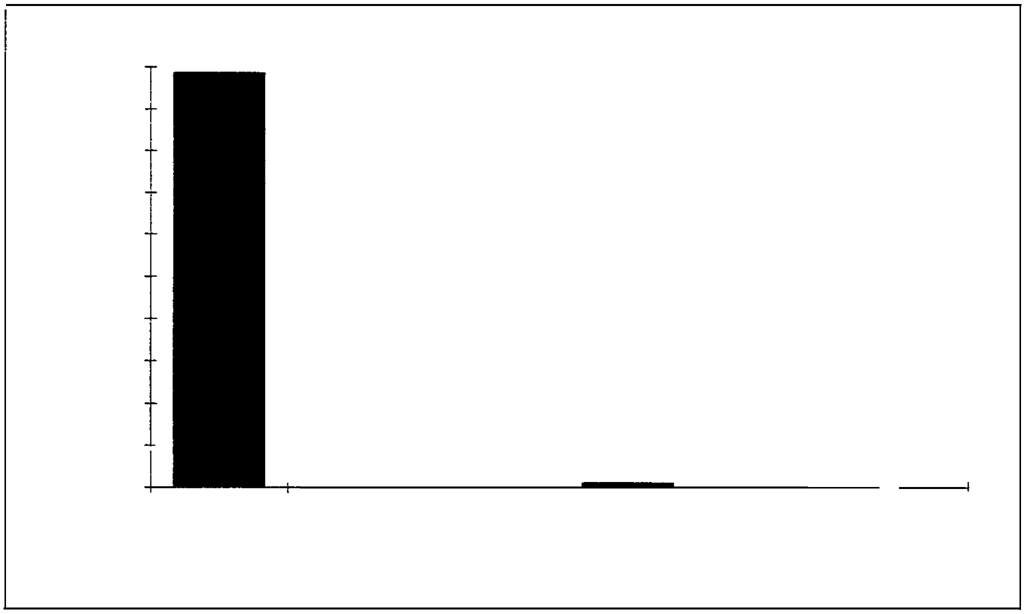

Figure 2.3-4 Percent of Rear-End Collisions vs. Road Alignment (Texas 1990)

Table 2.3-5 Number of Rear-End Collisions by Road Surface Condition (Texas 1990)

Road Surface Condition	Number of Rear-end Collisions	Percent of Rear-end Collisions
Dry	85818	79.50%
Wet	21625	20.03%
Muddy	44	0.04%
Snowy/Icy	746	0.69%
TOTAL	107949	100.00%

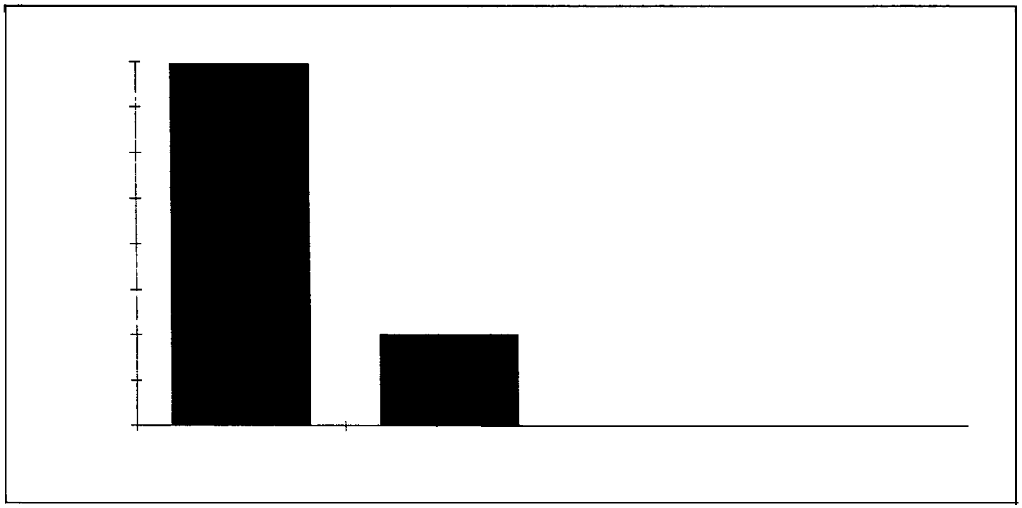

Figure 2.3-5 Percent of Rear-End Collisions vs. Road Surface Condition (Texas 1990)

Table 2.3-6 Number of Rear-End Collisions Vs Road Pavement Condition (Texas 1990)

Road Pavement Condition	Number of Rear-end Collisions	Percent of Rear-end Collisions
No defects	95505	88.47%
Holes, ruts, etc., in surface	63	0.06%
Defective shoulder	3	0.00%
Foreign material on surface	78	0.07%
High water or flood debris	33	0.03%
Slick surface	5753	5.33%
Obstruction in road, not lighted (night)	0	0.00%
Obstruction in road, not marked (day)	0	0.00%
Narrow bridge, overpass, or underpass	1	0.00%
Road under construction	6509	6.03%
Maintenance or repair activity affecting traffic	14	0.01%
TOTAL	107949	100.00%

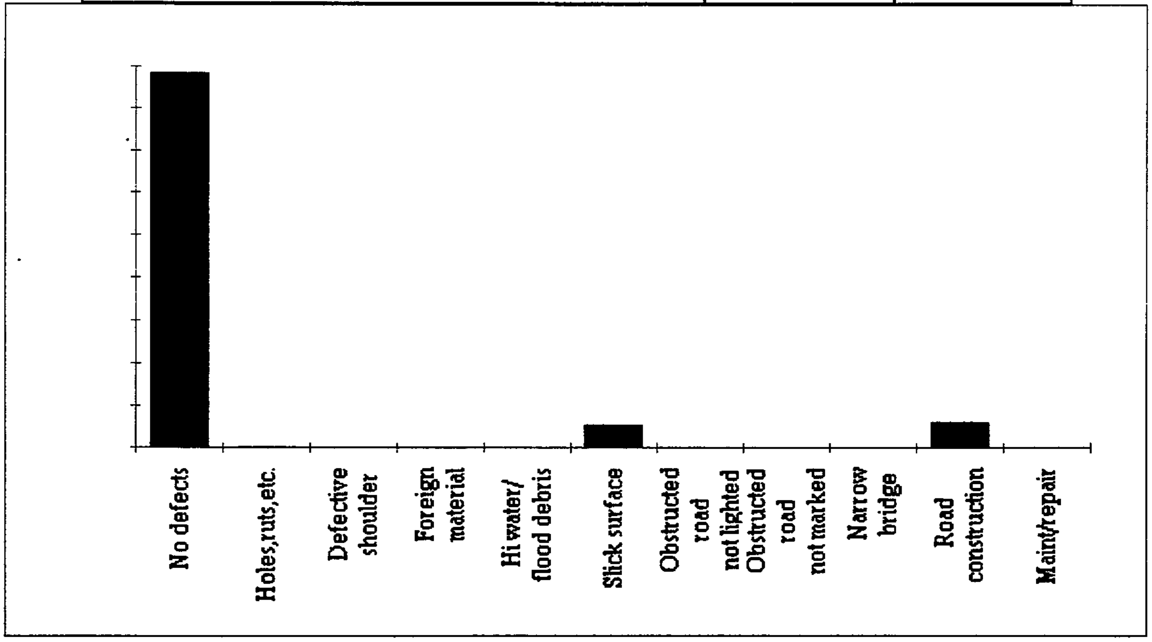

Figure 2.3-6 Percent of Rear-End Collisions vs. Road Pavement Condition (Texas 1990)

Table 2.3-7 Number of Rear-End Collisions vs. Type of Traffic Control Device (Texas 1990)

Traffic Control Device	Number of Rear-end Collisions	Percent of Rear-end Collisions
None present or inoperative	6650	6.16%
Officer, flagman, or watchman	450	0.42%
Stop and go signal	23063	21.36%
Stop sign	5064	4.69%
Flashing red light	210	0.19%
Turn Marks	687	0.64%
Warning sign	278	0.26%
Railroad gates or signal	170	0.16%
Yield sign	3364	3.12%
Center stripe or divide]	66562	61.66%
No passing zone	867	0.80%
Other traffic control	**729**	**0.68%**
TOTAL	**107949**	**100.00%**

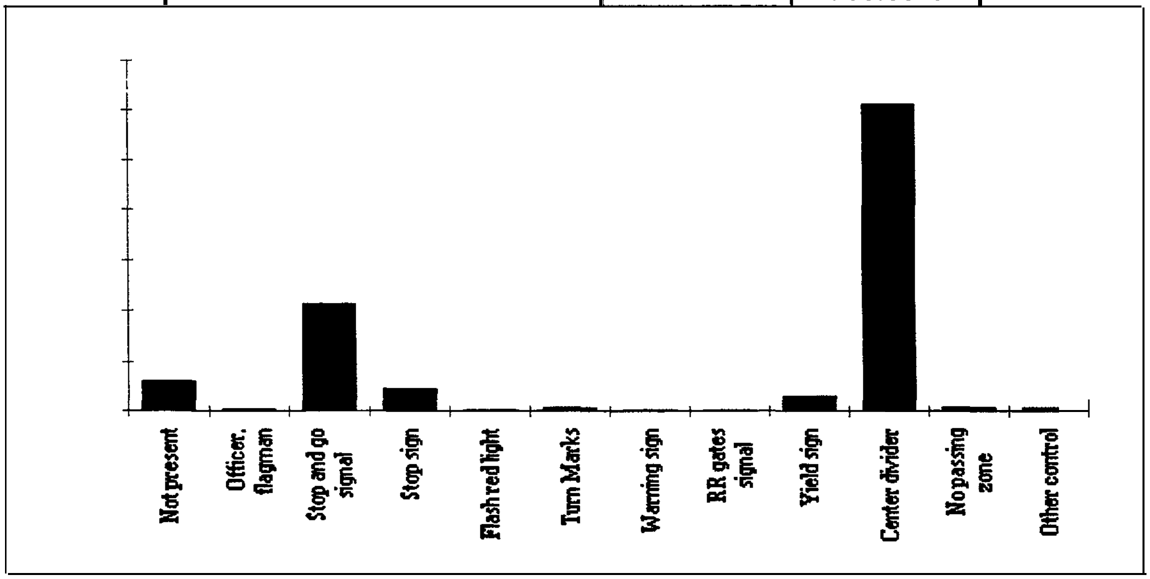

Figure 2.3-7 Percent of Rear-End Collisions vs. Type of Traffic Control Device (Texas 1990)

Table 2.3-8 Number of Rear-End Collisions vs. Relationship to Intersection (Texas 1990)

Relationship to Intersection	Number of Rear-end Collisions	Percent of Rear-end Collisions
Intersection	12977	12.02%
Intersection related	36177	33.51%
Driveway access	14188	13.14%
Non-intersection	44868	41.56%
TOTAL	107949	100.00%

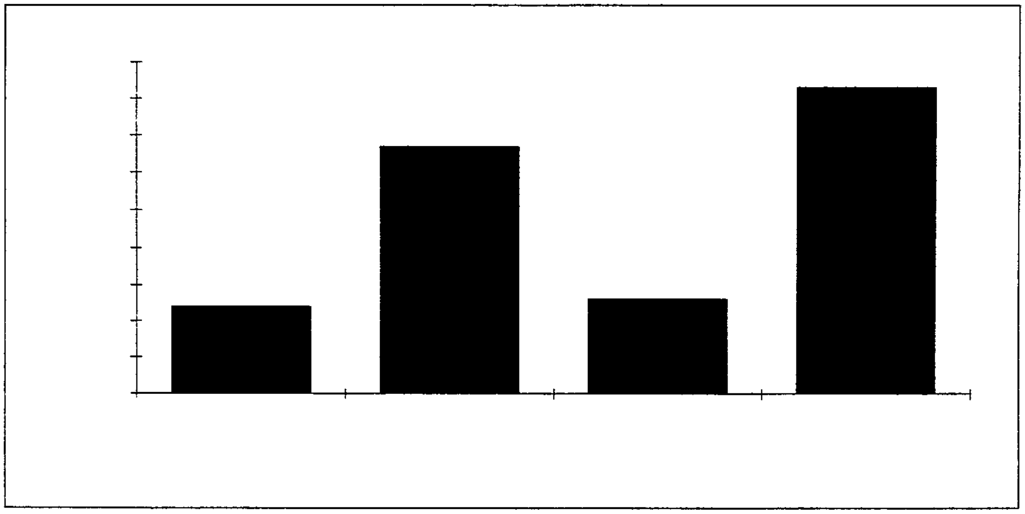

Figure 2.3-8 Percent of Rear-End Collisions vs. Relationship to Intersection (Texas 1990)

Table 2.3-9 Number of Rear-End Collisions vs. Number of Entering Roads (Texas 1990)

Number of Entering Roads	Number of Rear-end Collisions	Percent of Rear-end Collisions
Not applicable	58932	60.99%
3 entering roads - T	12850	13.30%
3 entering roads - Y	4219	4.37%
4 entering roads - crossing or other	31952	33.07%
5 entering roads	80	0.08%
6 entering roads	7	0.01%
Traffic circle (at or within intersection)	83	0.09%
Cloverleaf	9	0.01%
TOTAL	96629	100.00%

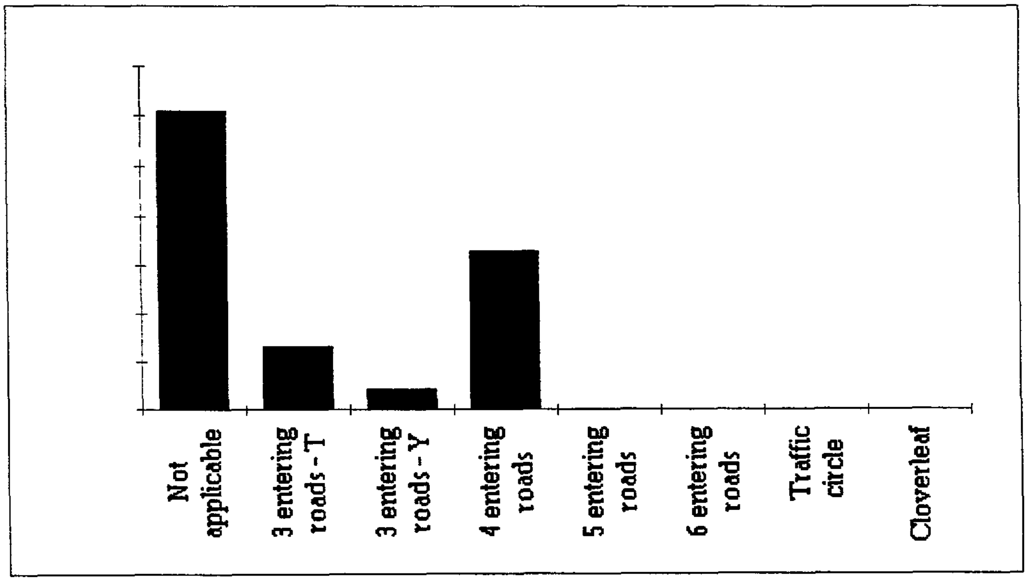

Figure 2.3-9 Percent of Rear-End Collisions vs. Number of Entering Roads (Texas 1990)

Table 2.3-10 Number of Rear-End Collisions vs. Selected Roadway Features #1 (Texas 1990)

Roadway Feature #1	Number of Rear-end Collisions	Percent of Rear-end Collisions
Private drive or road	11006	10.20%
Service station	320	0.30%
Cafe or grocery parking lot	650	0.60%
Shopping center lot, entrance or exit	267	0.25%
Tavern or liquor store	26	0.02%
Drive-in theater	0	0.00%
Other business entrance or exit	2100	1.95%
Factory or plant entrance or exit	22	0.02%
Military or naval entrance or exit	6	0.01%
Governmental area entrance or exit	122	0.11%
Other roadway feature not a factor	93704	86.80%
TOTAL	107949	100.00%

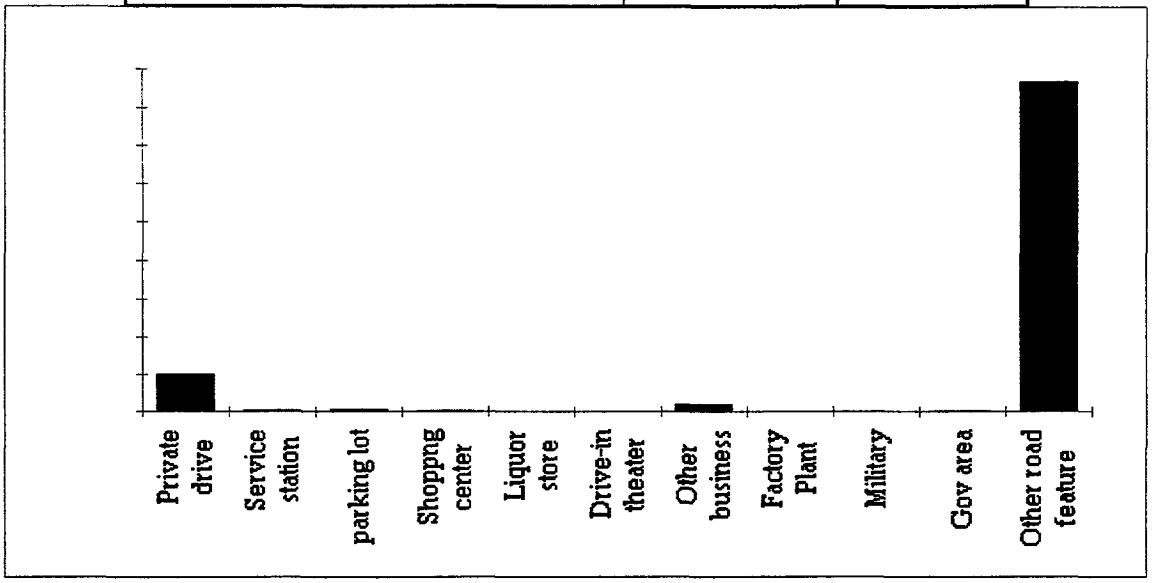

Figure 2.3-10 Percent of Rear-End Collisions vs. Selected Roadway Features #1 (Texas 1990)

Table 2.3-11 Number of Rear-End Collisions vs. Selected Roadway Features #2 (Texas 1990)

Roadway Feature #2	Number of Rear-end Collisions	Percent of Rear-end Collisions
Alley	160	0.15%
Parking area within right of way	48	0.04%
Roadside park entrance or exit	18	0.02%
Opening in median	696	0.64%
Crossover from one frontage road to another	180	0.17%
At detour	4	0.00%
RR grade crossing	353	0.33%
School	148	0.14%
Church/cemetery	70	0.06%
One or more traffic lanes closed for repair	532	0.49%
Other roadway feature not a factor	106060	98.25%
TOTAL	107949	100.00%

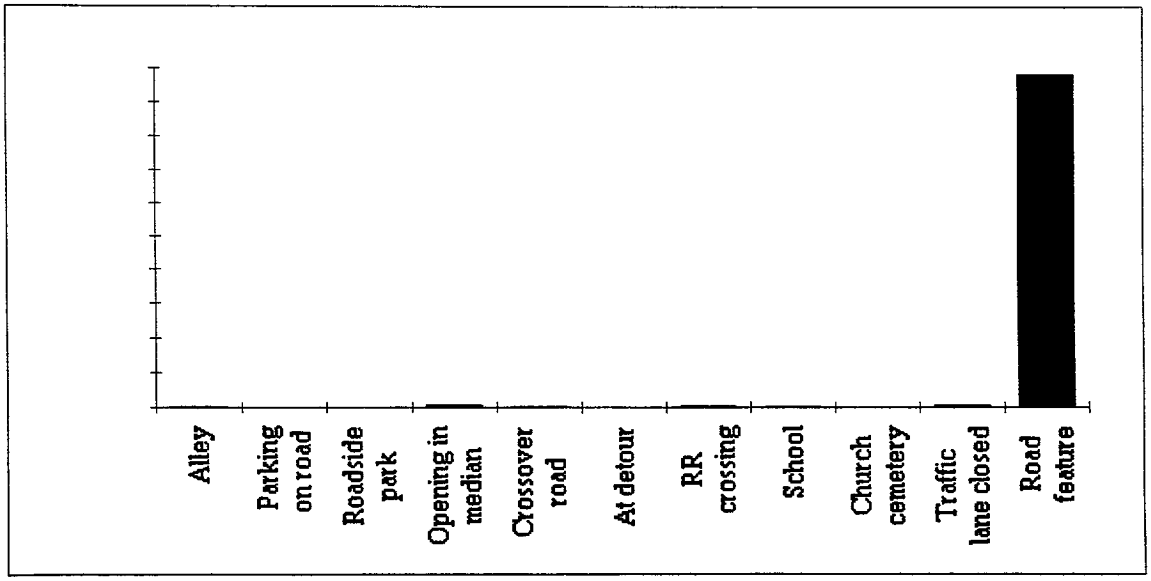

Figure 2.3-11 Percent of Rear-End Collisions vs. Selected Roadway Features #2 (Texas 1990)

Table 2.3-12 Number of Rear-End Collisions vs. Weather Condition (Texas 1990)

Weather Condition	Number of Rear-end Collisions	Percent of Rear-end Collisions
Clear or cloudy	91579	84.84%
Rain	15202	14.08%
Snow	173	0.16%
Fog	709	0.66%
Blowing dust	42	0.04%
Smoke	16	0.01%
Other	8	0.01%
Sleeting	346	0.32%
TOTAL	107949	100.00%

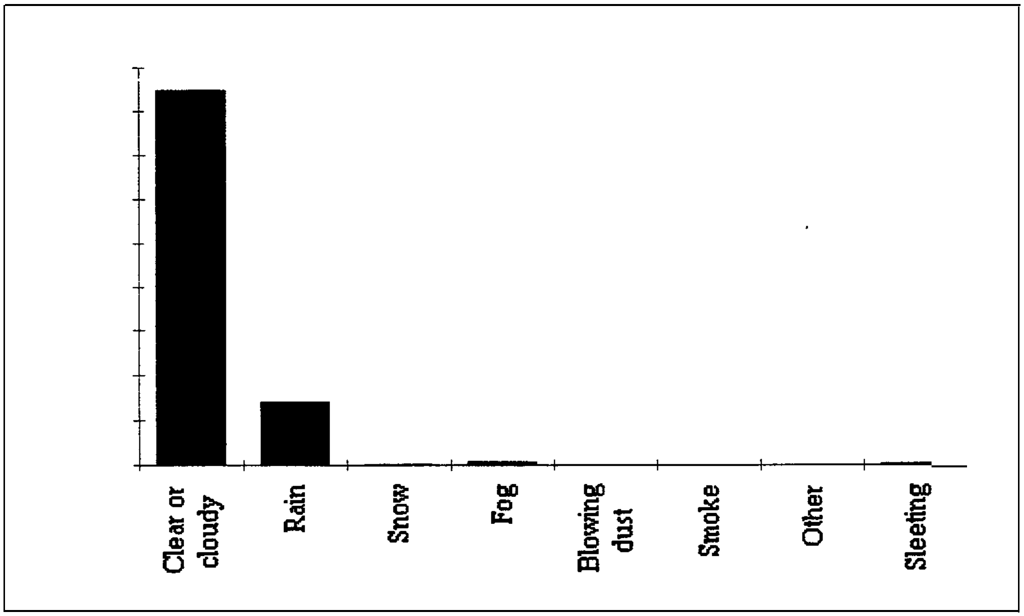

Figure 2.3-12 Percent of Rear-End Collisions vs. Weather Condition (Texas 1990)

Table 2.3-13 Number of Rear-End Collisions vs. Light Condition (Texas 1990)

Light Condition	Number of Rear-end Collisions	Percent of Rear-end Collisions
Daylight	82198	76.15%
Dawn	981	0.91%
Darkness - no street lights	6839	6.34%
Darkness - street lights	16305	15.10%
Dusk	1839	1.70%
TOTAL	107949	100.00%

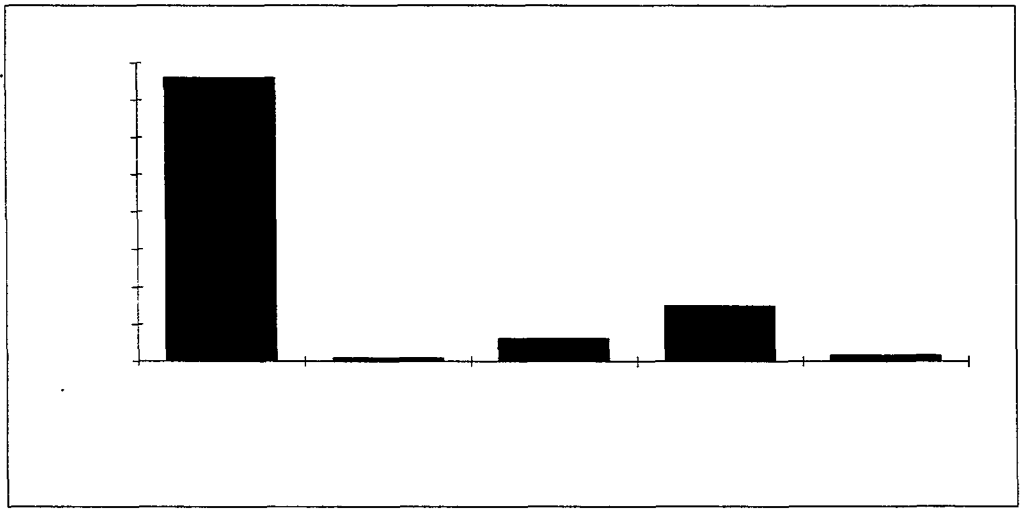

Figure 2.3-13 Percent of Rear-End Collisions vs. Light Condition (Texas 1990)

Table 2.3-14 Number of Rear-End Collisions vs. Traffic Unit Mix (Texas 1990)

Traffic Unit Mix	Number of Rear-end Collisions	Percent of Rear-end Collisions
Single vehicle	0	0.00%
Car - car	35444	33.46%
Car - truck	40090	37.84%
Car - motorcycle	644	0.61%
Car - other	759	0.72%
Truck - truck	11182	10.56%
Truck-motorcycle	326	0.31%
Truck - other	401	0.38%
Motorcycle-motorcycle	22	0.02%
Motorcycle-other	5	0.00%
Other - other	18	0.02%
Three or more vehicles	16990	16.04%
TOTAL	105936	100.00%

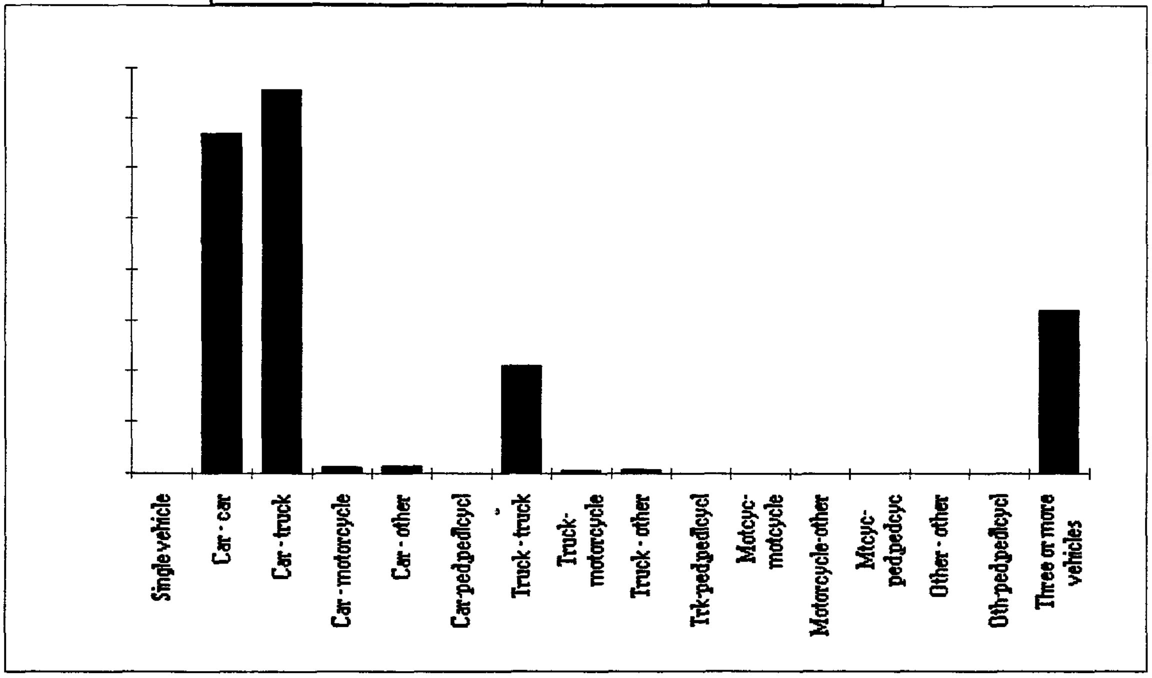

Figure 2.3-14 Percent of Rear-End Collisions vs. Traffic Unit Mix (Texas 1990)

Table 2.3-l 5 Number of Rear-End Collisions for Various Contributing Factors (Texas 1990)

Contributing Factor	Rear-ends	Percent
Avoid a vehicle stopping or slowing	24288	22.40%
No code shown applies	21441	19.77%
Avoid officer, flagman	19449	17.94%
Make left turn	8386	7.73%
Vehicle entering driveway	7989	7.37%
Reason not specified	6376	5.88%
Highway construction related	5802	5.35%
Make right turn	2367	2.18%
Vehicle passing on left	1978	1.82%
Vehicle changing lane	1126	1.04%
Vehicle moving forward from parking	1042	0.96%
Vehicle parked in improper location	913	0.84%
Attention diverted from driving	894	0.82%
School bus involved	821	0.76%
Highway (not construction related)	777	0.72%
Swerved to avoid previous crash	733	0.68%
Vehicle passing on right	678	0.62%
Swerved to avoid vehicle entering road	533	0.49%
Vehicle moving backward from parking	390	0.36%
Lost control or skidded	279	0.26%
Swerved to avoid pedestrian or pedalcyclist in road	247	0.23%
Swerved to avoid animal in road	211	0.19%
Swerved to avoid object in road	185	0.17%
Open door or object projecting from vehicle	183	0.17%
Swerved because of surface or visibility	147	0.14%
One vehicle leaving driveway	146	0.13%

Table 2.3-15 Number of Rear-End Collisions for Various Contributing Factors (Texas 1990) Continued

Contributing Factor	Rear-ends	Percent
Other visual obstruction	117	0.11%
Headlight or sun glare	110	0.10%
Foot slipped off clutch or brake	90	0.08%
Swerved to avoid a vehicle stopping or slowing	80	0.07%
Swerved to avoid a passing vehicle	64	0.06%
Swerved to avoid a vehicle entering road	50	0.05%

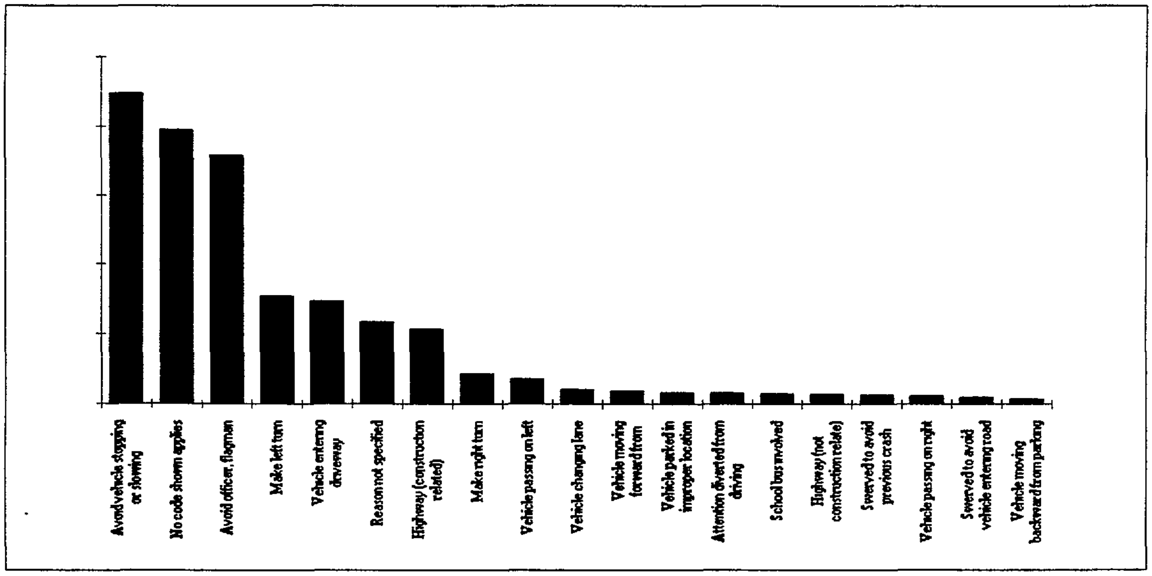

Figure 2.3-15 Percent of Rear-End Collisions for Various Contributing Factors (Texas 1990)

Table 2.3-16 Number of Rear-End Collisions vs. Worst Injury in Accident (Texas 1990)

Worst Injury in Accident	Number of Rear-end Collisions	Percent of Rear-end Collisions
K - fatal	170	0.16%
"A" incapacitating injury	2686	2.49%
"B" non incapacitating injury	9814	9.09%
"C" possible injury	36024	33.37%
No injury	59439	55.06%
Total	108133	100.00%

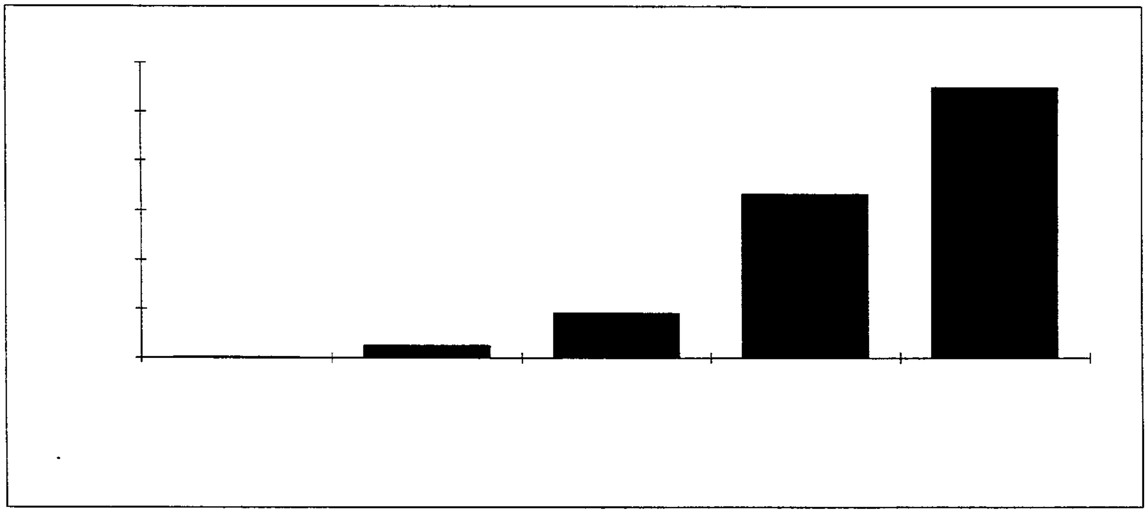

Figure 2.3-13 Percent of Rear-End Collisions vs. Worst Injury in Accident (Texas 1990)

SECTION 3
1992 NASS GES ANALYSIS

This section contains an overview of some of the variables presented in the 1992 NASS GES. The 1992 NASS GES file was just recently made available to the public and this analysis was performed to update and augment information presented in the NHTSA report. Unfortunately the weighting factors in the 1992 NASS GES available at the time of this analysis were incorrectly calculated, and consequently, the statistics presented in this section are unweighted. Due to this problem with the weighting factors in the 1992 NASS GES database, data will not be presented in tabulated form because the statistics do not necessarily represent the population of rear-end collisions.

The statistics of some of the accident variables in the 1992 NASS GES data have been determined. Where appropriate a comparison is made to information in the NHTSA report which is based on the 1990 NASS GES and the NHTSA FARS. The variables studied are as follows:

1. Accident type
2. Lead vehicle moving or stationary
3. Pre-crash variables (new GES variables)
4. Atmospheric condition
5. Light condition
6. Roadway surface condition
7. Roadway alignment
8. Roadway profile
9. Land use
10. Relation to junction
11. Relation to interstate
12. Number of vehicle travel lanes
13. Alcohol involvement
14. Driver vision obscured by
15. Driver maneuver to avoid
16. Driver distracted by

Accidents involving more than two vehicles (2+ vehicles involved) are coded into their own variable. This may cause some variables to be over-represented or under-represented.

As can be seen from Figure 3.1-1 almost sixty percent of rear-end collisions had the lead vehicle stopped. Lead vehicle slower is almost twice as likely as lead vehicle decelerating, as opposed to the NHTSA report data where these two conditions were nearly equal. This provides a coarse break-down of the rear-end collision.

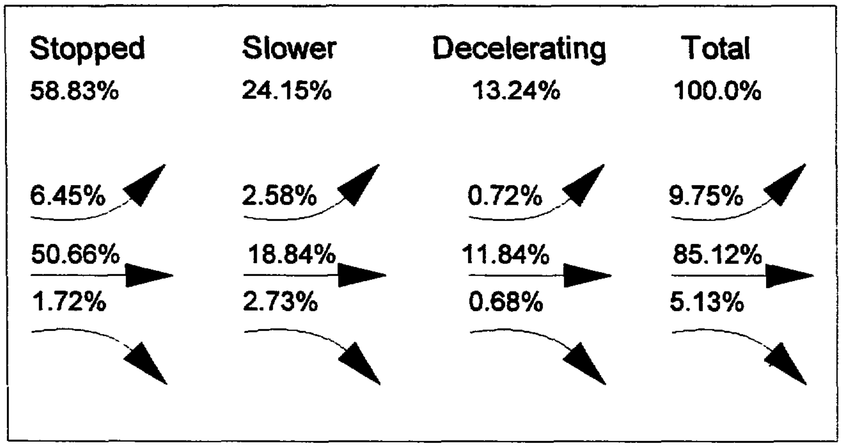

Figure 3.1-1 Percentage of Rear-End Collisions by Lead Vehicle Accident Type (92 GES)

Figure 3.1-2 shows the data from Figure 3.1-1 in a slightly different form. From this data, which excludes unknowns, it can be seen that almost sixty percent of the rear-end collisions are coded as lead vehicle stopped (LVS) and almost forty percent are coded as lead vehicle moving (LVM). These two cases, lead vehicle stopped and lead vehicle moving, are dramatically different when estimating the task of a rear-end collision avoidance system. This information supports the findings of the NHTSA report.

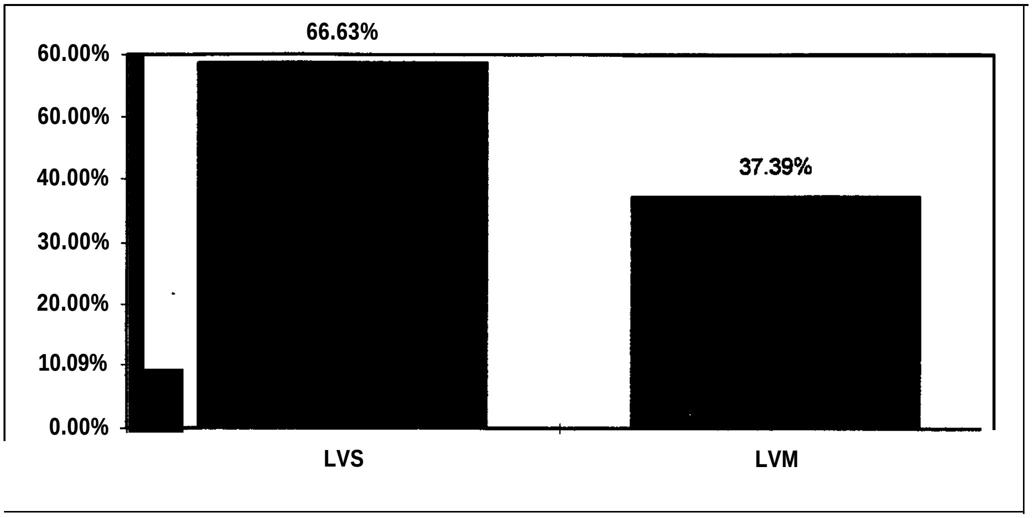

Figure 3.1-2 Percent of Rear-End Collisions vs. Lead Vehicle Moving or Stationary (92 GES)

New to the 1992 NASS GES are the five pre-crash variables. These variables are meant to provide insight into the events leading up to the collision. The five pre-crash variables in order are:

1. Movement prior to critical event (Precrash 1).
   The attribute which best describes this vehicle 's activity prior to the driver 's realization of an impending critical event.
2. Critical event (Precrash 2).
   This variable identifies the critical event which made the crash imminent.
3. Corrective action attempted (Precrash 3).
   Corrective actions are movements/actions attempted by the driver to avoid an impending impact after realization of an impending danger, but before the actual event.
4. Vehicle control after corrective action (Precrash 4).
   Assesses the stability of the vehicle during the period between the corrective action attempted and up to the initial impact.
5. Vehicle path after corrective action (Precrash 5).
   Assesses the consequences of the corrective action.

Figure 3.1-3 through Figure 3.1-7 are the pre-crash variables as they relate to the striking vehicle. Figure 3.1-3 shows the first pre-crash variable for the striking vehicle. As can be seen, the most commonly coded striking vehicle movement prior to critical event is going straight. Striking vehicle slowing or stopping occurs only about six percent of the time. Other choices for this variable are coded infrequently.

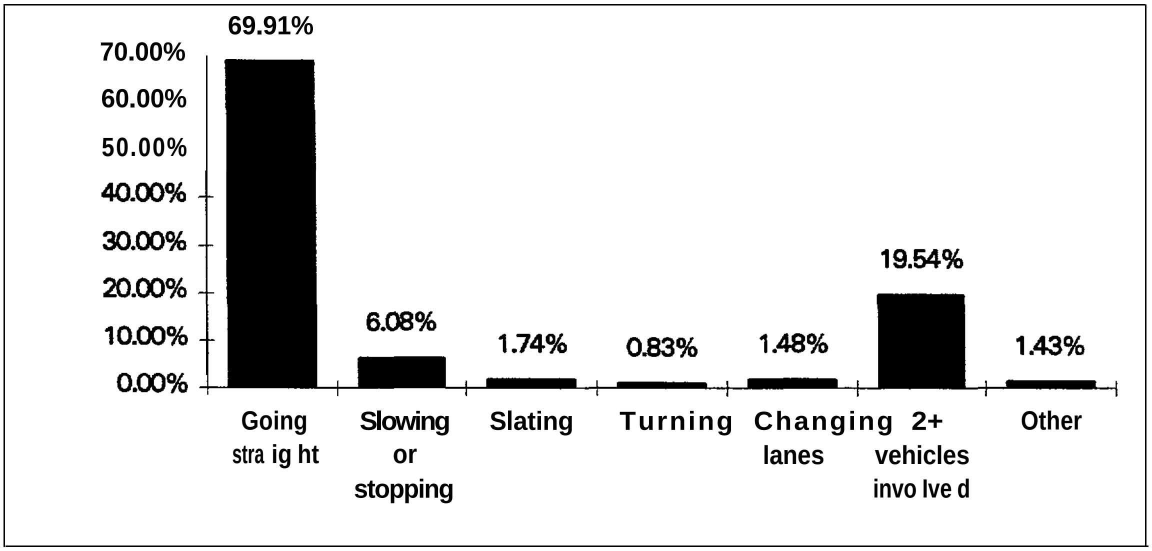

Figure 3.1-3 Percent of Rear-End Collisions vs. Striking Vehicle Movement Prior to Critical Event (92 GES)

As can be seen from Figure 3.1-4, the most commonly coded striking vehicle critical event is the striking vehicle higher velocity. This data does not compare with the data presented in Figure 3. l-l, accident type. This is probably due to a non-unique choice for coding of this variable. For a rear-end collision coded as lead vehicle stationary, or moving, the striking vehicle critical event can be coded as striking vehicle higher velocity. Since this variable is new to the GES, it is likely that there are coding problems. Changes are warranted in the coding of this variable to make each selection more unique and consistent with other variables present within the 1992 NASS GES.

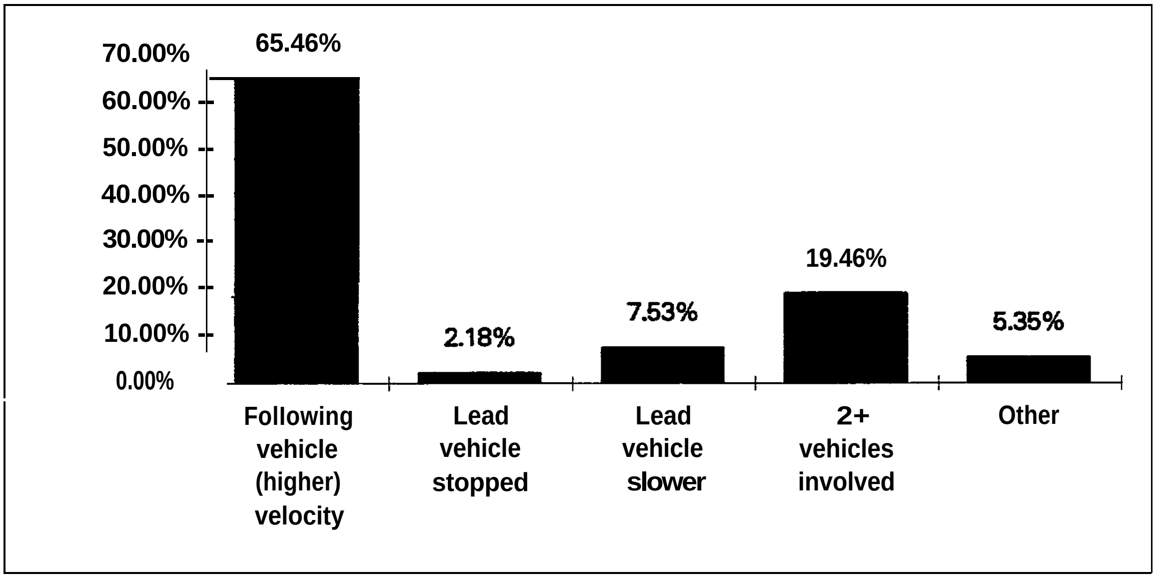

Figure 3.1-4 Percent of Rear-End Collisions vs. Striking Vehicle Critical Event (92 GES)

Figure 3.1-5 shows the striking driver's corrective action attempted. As can be seen, the most common code is no corrective action attempted. Braking or slowing is only occurring in about thirteen percent of the rear-end collisions. The clinical analysis of hard copy files, such as the 1992 NASS CDS, do not support this data. An analysis of the 1992 NASS CDS found only twenty percent of the striking vehicle drivers had no corrective action.

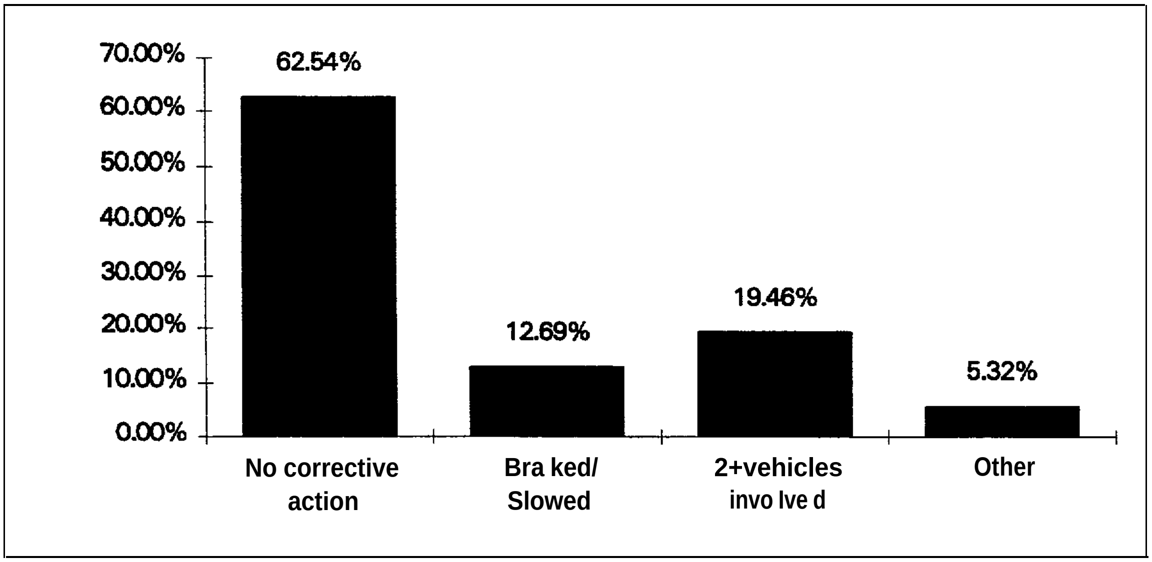

Figure 3.1-5 Percentage of Rear-End Collisions vs. Striking Vehicle Corrective Action Attempted (92 GES)

Because the striking vehicle corrective action attempted is most commonly coded as no corrective action, both the striking vehicle control after corrective action and striking vehicle path after corrective action are coded as no corrective action. This can be seen by examining Figure 3.1-6 and Figure 3.1-7. As stated previously for Figure 3.1-5, this is misleading and possibly incorrect. Care should be taken when using the precrash 3, 4 and 5 variables to estimate events for the striking vehicle.

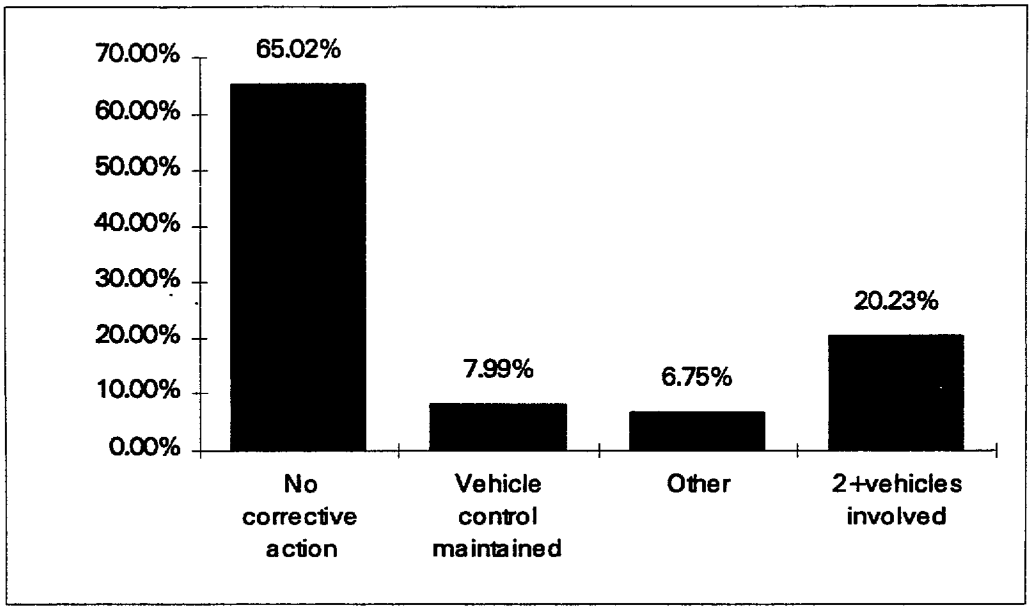

Figure 3.1-6 Percent of Rear-End Collisions vs. Striking Vehicle Control After Corrective Action (92 GES)

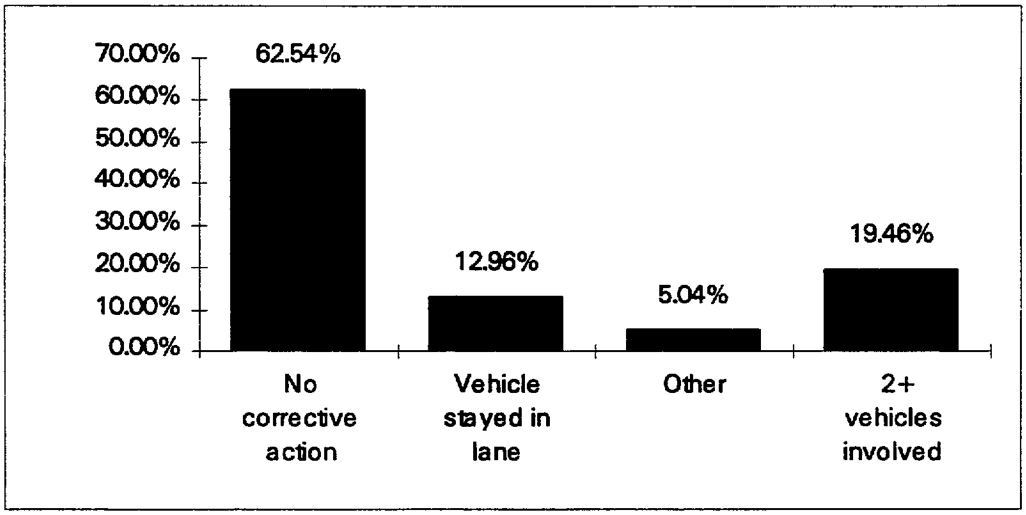

Figure 3.1-7 Percent of Rear-End Collisions vs. Striking Vehicle Path After Corrective Action (92 GES)

Figure 3.1-8 through Figure 3.1-12 are the pre-crash variables as they relate to the struck (lead) vehicle. Figure 3.1-8 shows the struck (lead) vehicle movement prior to critical event. As can be seen, this variable compares well with the accident type presented in

Figure 3.1-1. The most commonly coded struck vehicle movement prior to critical event is stopped.

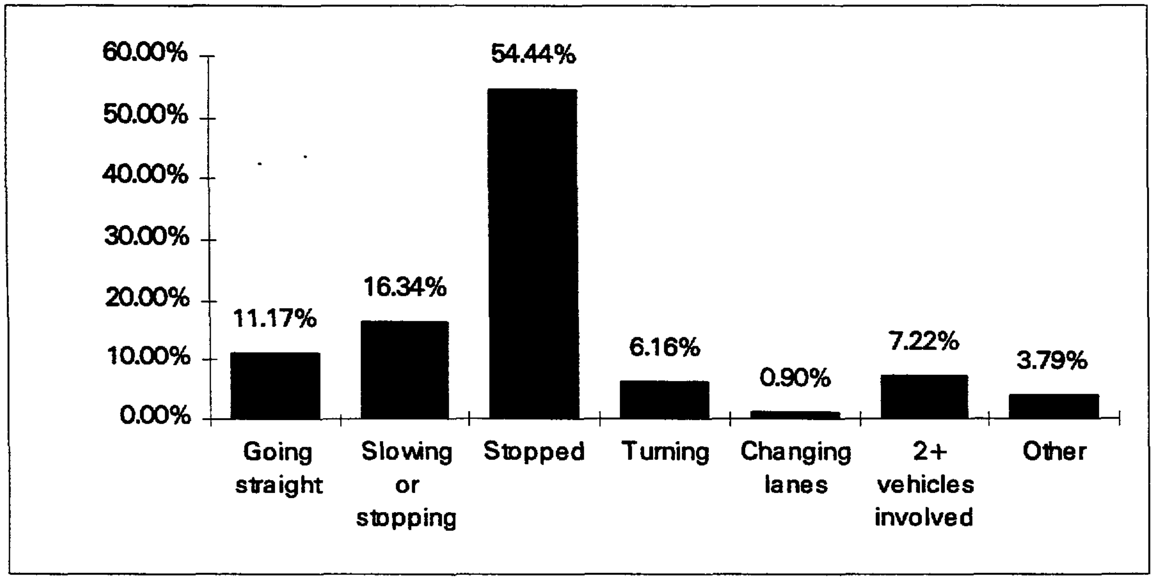

Figure 3.1-8 Percent of Rear-End Collisions vs. Struck Vehicle Movement Prior to Critical Event (92 GES)

Figure 3.1-9 shows the coding of the struck vehicle critical event. The coding of the critical event for the struck vehicle can be confusing, because the coding is not specific, or unique. Lead vehicle stopped or following vehicle higher velocity could apply to the same collision.

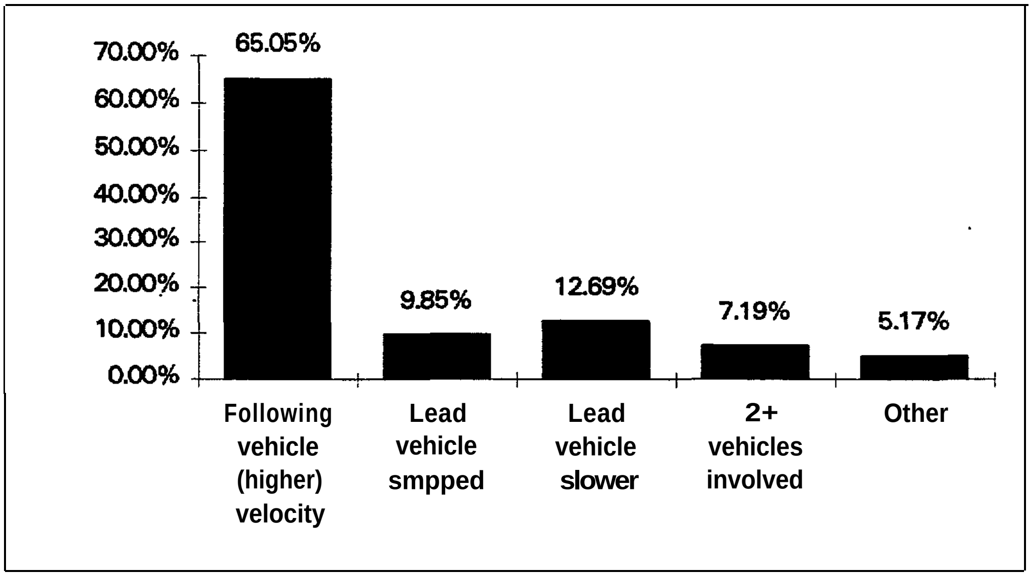

Figure 3.1-9 Percent of Rear-End Collisions vs. Struck Vehicle Critical Event (92 GES)

Figure 3.1-10 shows the struck (lead) vehicle corrective action attempted. This figure is intuitively obvious, because it is reasonable to assume that the struck vehicle never sees the striking vehicle and therefore no avoidance action is typically coded.

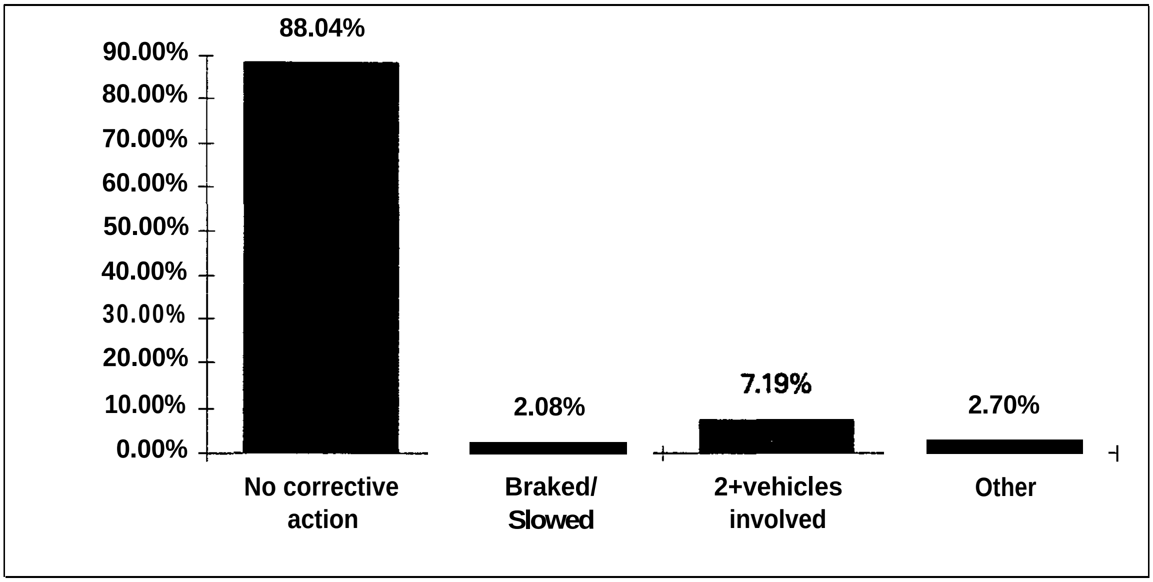

Figure 3.1-l 0 Percent of Rear-End Collisions vs. Struck Vehicle Corrective Action Attempted (92 GES)

Because the struck (lead) vehicle corrective action attempted is most commonly coded as no corrective action, both the struck vehicle control after corrective action and struck vehicle path after corrective action are coded as no corrective action. This can be seen by examining Figure 3.1-11 and Figure 3.1-12.

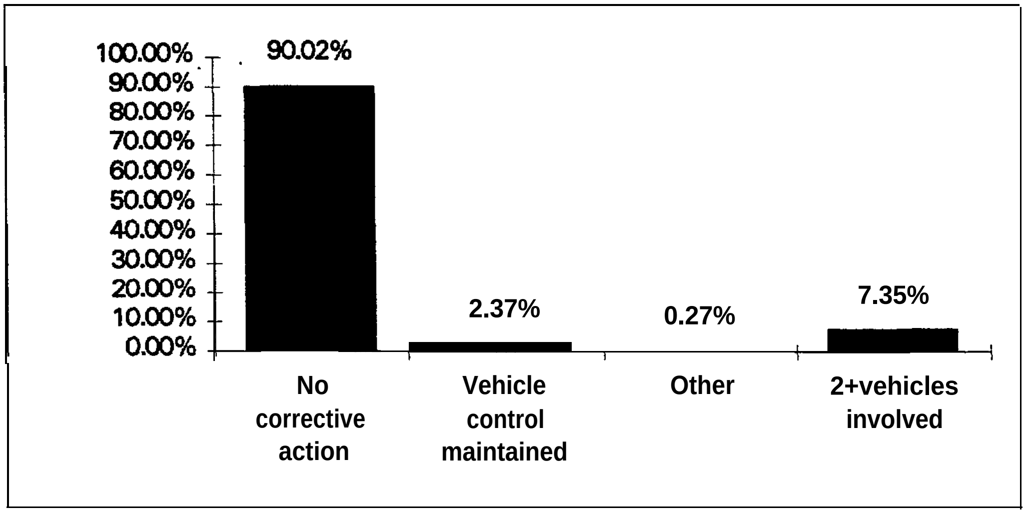

Figure 3.1-11 Percent of Rear-End Collisions vs. Struck Vehicle Control After Corrective Action (92 GES)

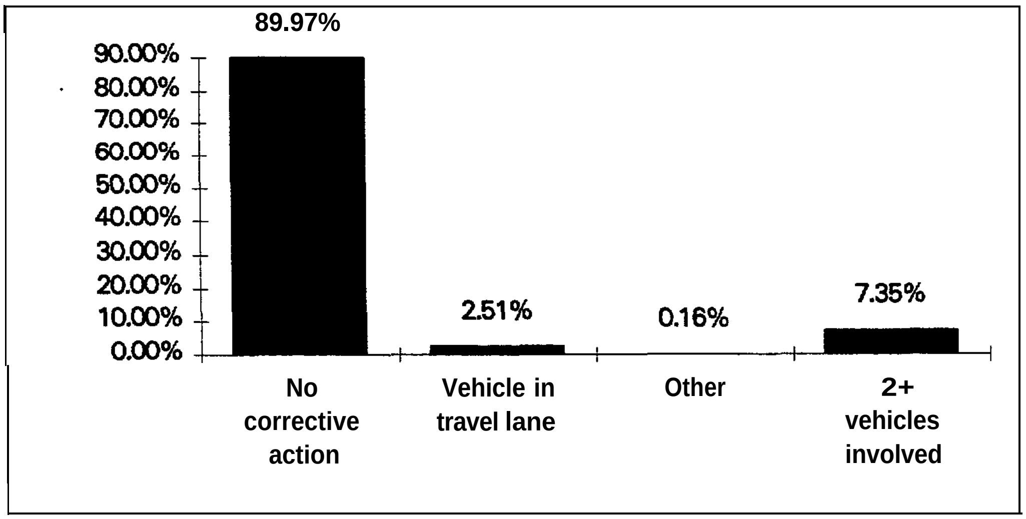

Figure 3.1- 12 Percent of Rear-End Collisions vs. Struck Vehicle Path After Corrective Action (92 GES)

Only two types of environmental conditions are variables in the 1992 NASS GES. They are the atmospheric condition as shown in Figure 3.1-13 and the light condition as shown in Figure 3.1-14. As can be seen, most rear-end collisions occur during clear weather conditions while seventeen percent of the accidents occur in ram. Rear-end collisions that occurred during snow, other or unknown atmospheric conditions were infrequent enough that they can be ignored for most purposes.

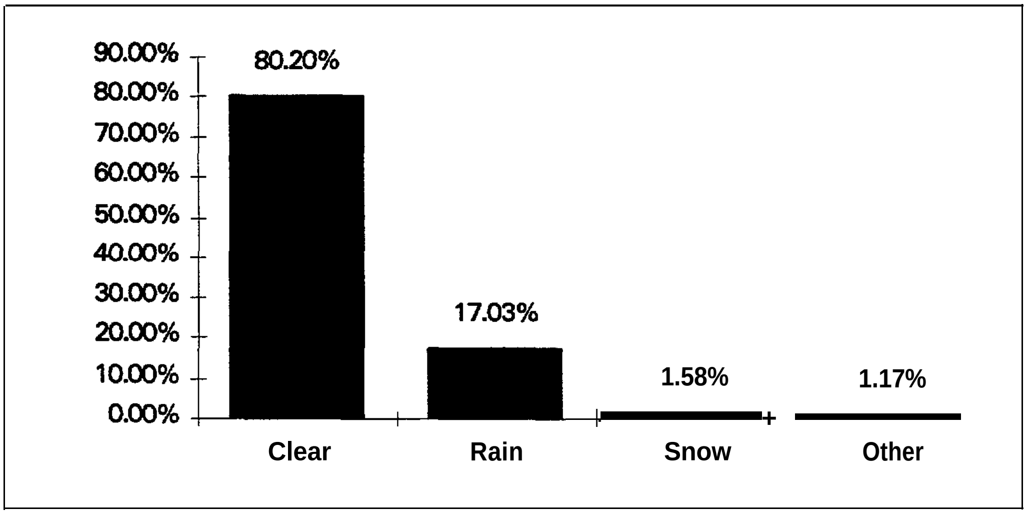

Figure 3. l-l 3 Percent of Rear-End collisions vs. Atmospheric Condition (92 GES)

Most rear-end collisions occur during daylight. The occurrence of collisions during dawn or dusk is infrequent enough that they can be ignored for most purposes.

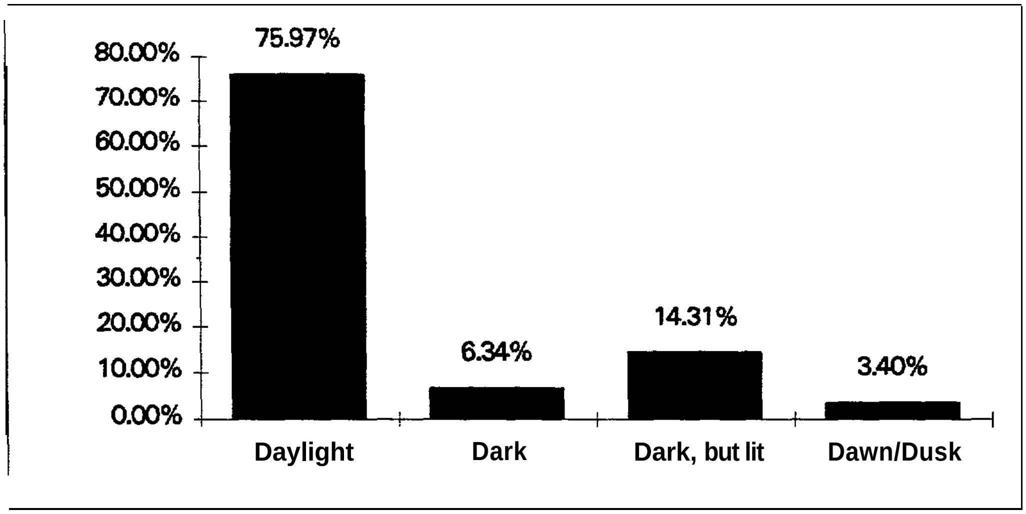

Figure 3.1-14 Percent of Rear-End Collisions vs. Light Condition (92 GES)

Figure 3. l-l 5 shows the percentage of rear-end collisions versus roadway surface conditions. By comparison of Figure 3. l-l 3 atmospheric condition with Figure 3. l-l 5 it can be determined that seventy-three percent of the rear-end collisions occur during dry, clear conditions, seventeen percent occur during rain and seven percent during clear and wet conditions.

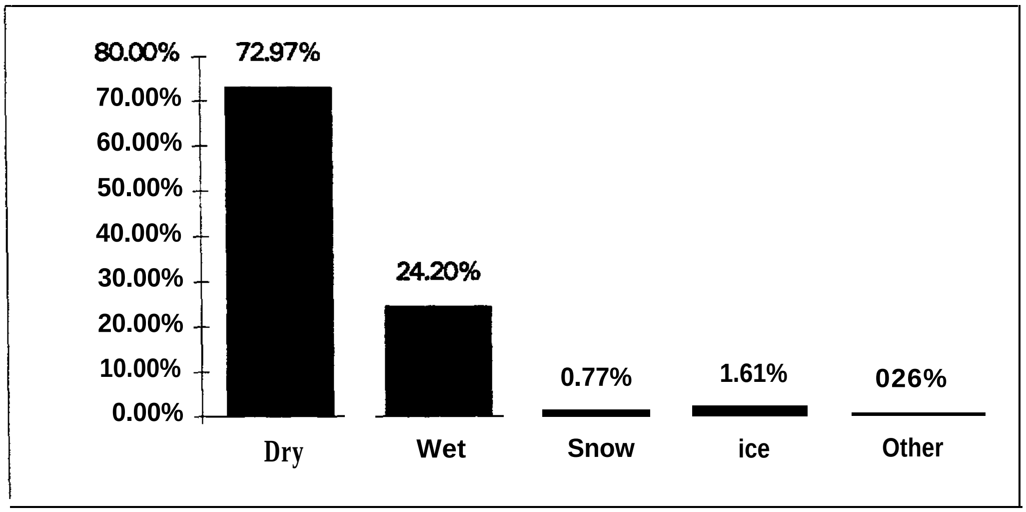

Figure 3.1- 15 Percent of Rear-End Collisions vs. Roadway Surface Condition (92 GES)

According to Figure 3. l-l 6 nearly ninety-five percent of rear-end collisions occur on straight roads. The straightness of a roadway might be over-represented with respect to a rear-end collision avoidance system. The 1992 NASS GES code book gives no guidance to the definition of a straight roadway. This could lead to an over-representation of straight roadways in the 1992 NASS GES data tile.

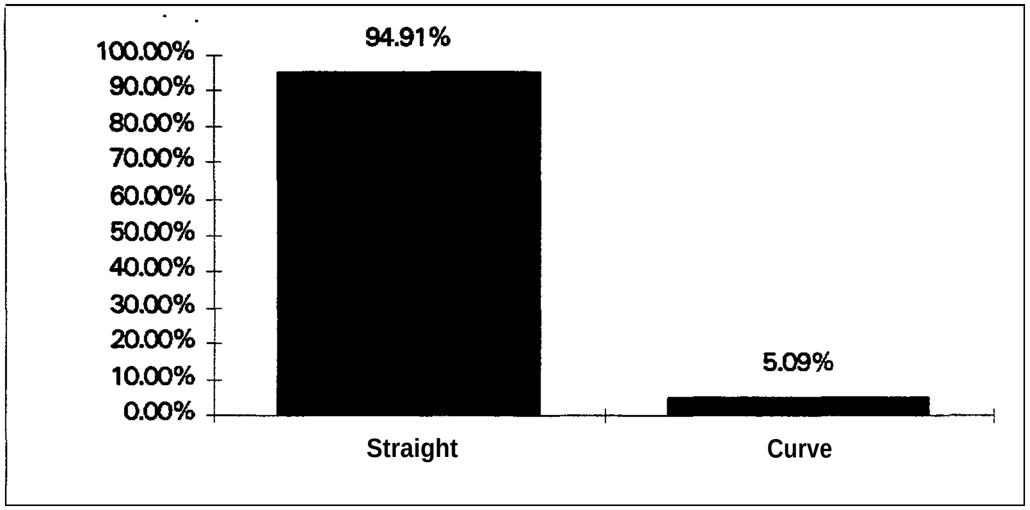

Figure 3.1-16 Percent of Rear-End Collisions vs. Roadway Alignment (92 GES)

As shown in Figure 3. l-l 7, the most commonly coded roadway profile is level. Roadways coded as grade occur only about twenty five percent of the time. Roadways coded as hillcrest, other or unknown were grouped together as other.

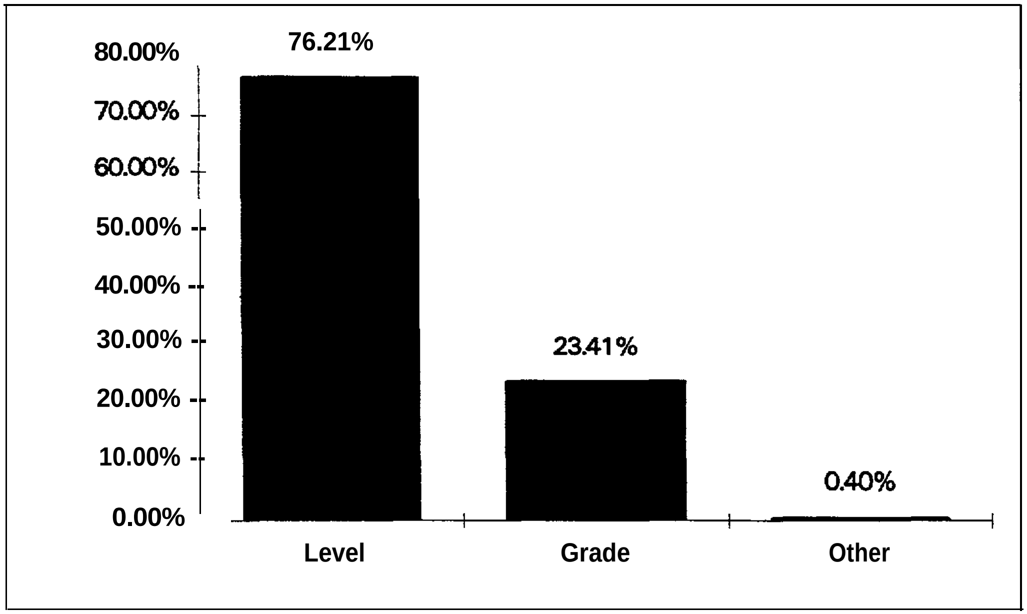

Figure 3. l-l 7 Percent of Rear-End Collisions vs. Roadway Profile (92 GES)

Figure 3. l-l 8 indicates that the largest number of rear-end collisions are associated with the "other area" category which is presumably more rural than 25,000 population.

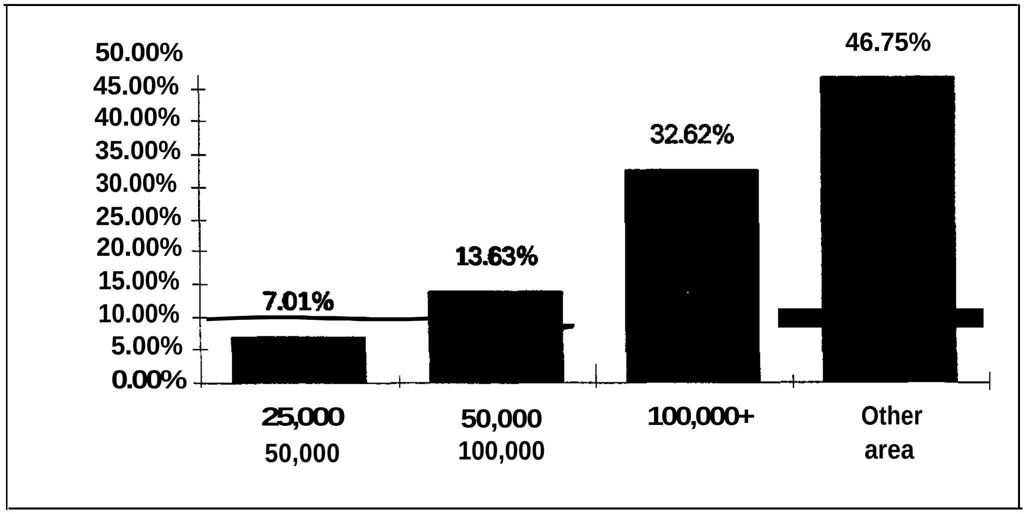

Figure 3.1-l 8 Percentage of Rear-End Collisions vs. Land use (population) (92 GES)

Figure 3.1-19 shows that rear-end collisions are more likely to happen in non-junction areas. Since sixty percent of the accidents occur with lead vehicle stationary and almost fifty percent are non-junction related, this data would indicate that ten percent of rear-end collisions occur with the struck driver stopped in the middle of the road. This doesn't seem likely.

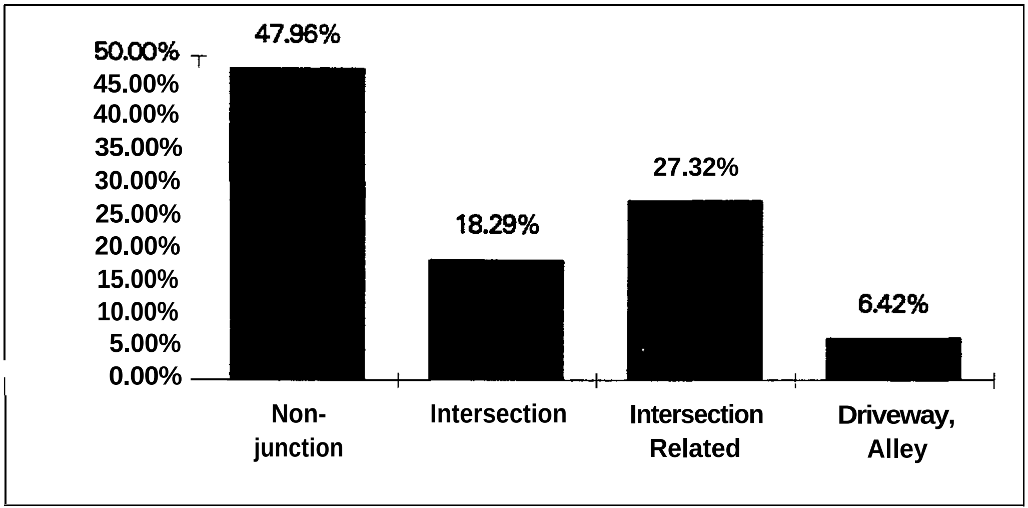

Figure 3. l-l 9 Percentage of Rear-End Collisions vs. Relation to Junction (92 GES)

Figure 3.1-20 shows that very few rear-end collisions happen on interstate highways.

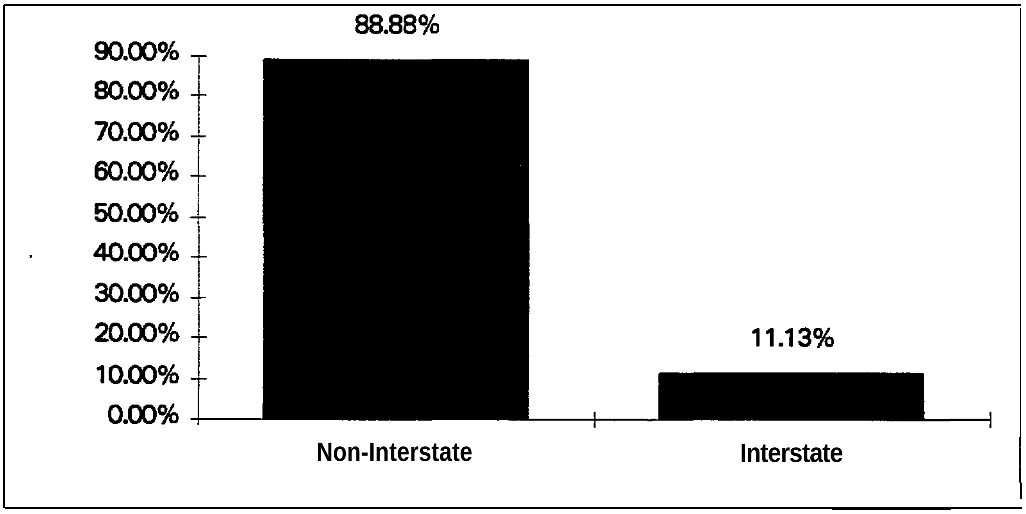

Figure 3.1-20 Percent of Rear-End Collisions vs. Interstate Highway (92 GES)

Figure 3.1-21 shows that the largest fraction of rear-end collisions occur on two-lane roads, where they account for less than twenty percent of all crashes. On all other types, more than thirty percent of the crashes are classified as rear-end.

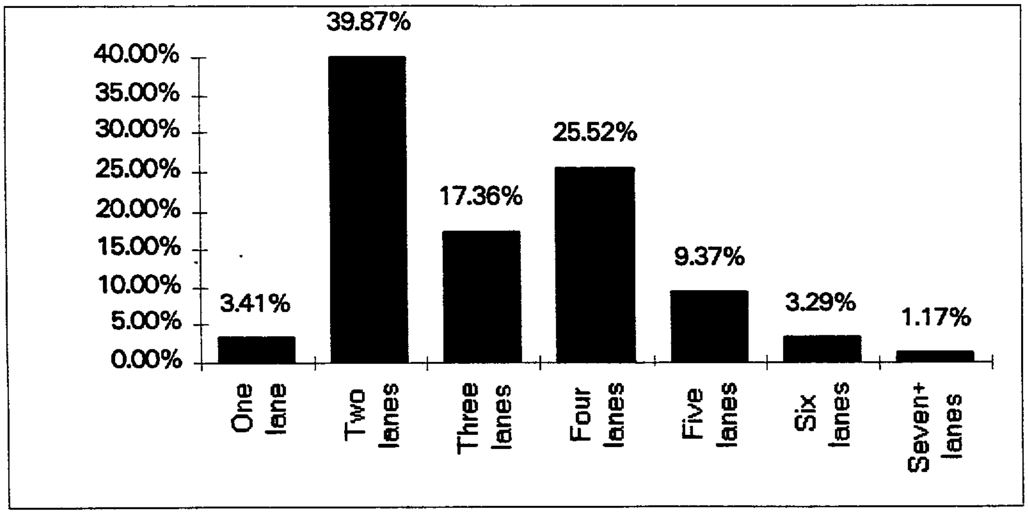

Figure 3.1-21 Percent of Rear-End Collisions vs. Number of Travel Lanes (92 GES)

Figure 3.1-22 shows the likelihood that alcohol is involved in a rear-end collision. As can be seen, alcohol is not a strong factor in rear-end collisions. Based on an analysis of hard copy CDS files it appears that alcohol involvement is under-represented in the GES.

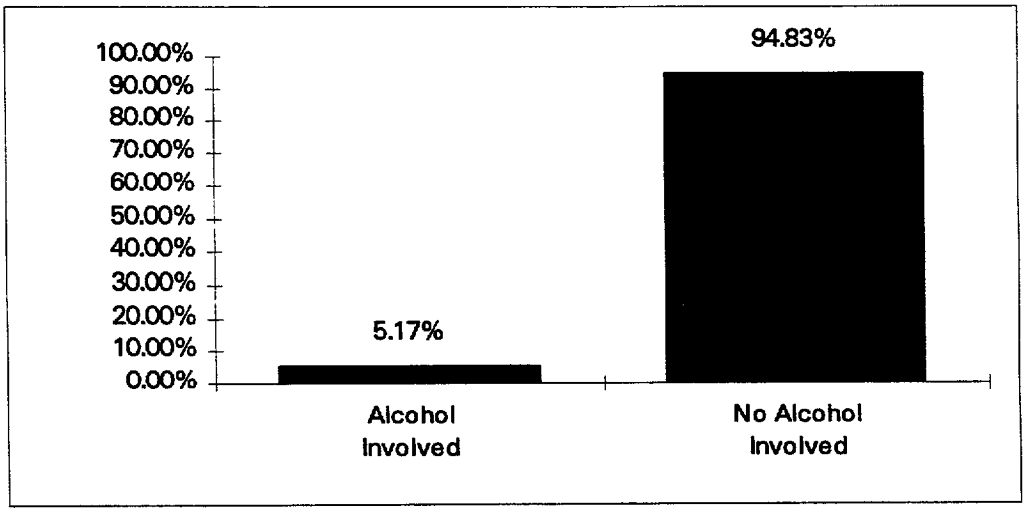

Figure 3.1-22 Percent of Rear-End Collisions vs. Striking Driver Alcohol Involved (92 GES)

As can be seen from Figure 3.1-25, the striking drivers vision was rarely obscured by an external influence. This reinforces the hard copy CDS analysis that showed that most rear-end collisions are caused or are a result of driver inattention and/or following too closely.

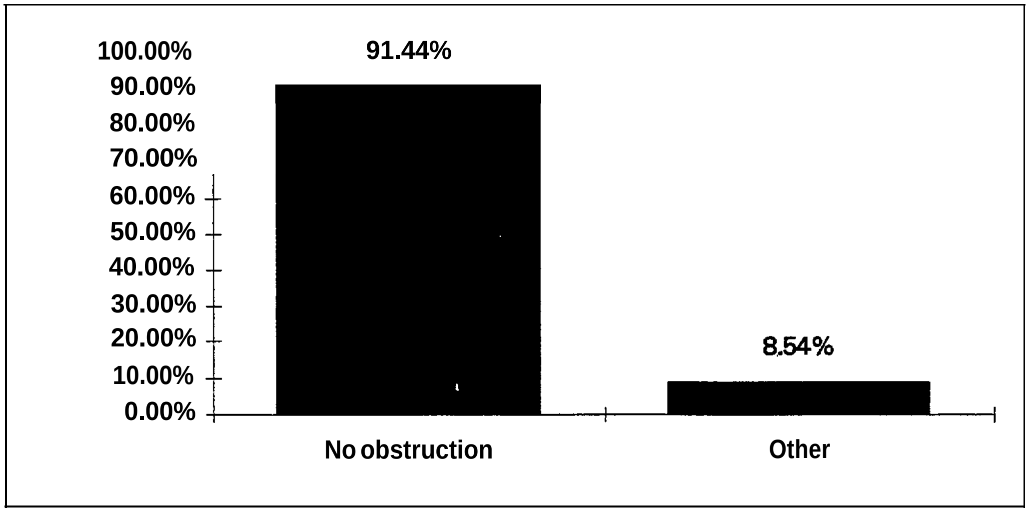

Figure 3.1-22 Percent of Rear-End Collisions vs. Striking Driver Vision Obscured By (92 GES)

The striking driver is rarely maneuvering to try to avoid something when the rear-end collision occurs, as shown in Figure 3 .l-23. This does not include trying to avoid the struck (lead) vehicle.

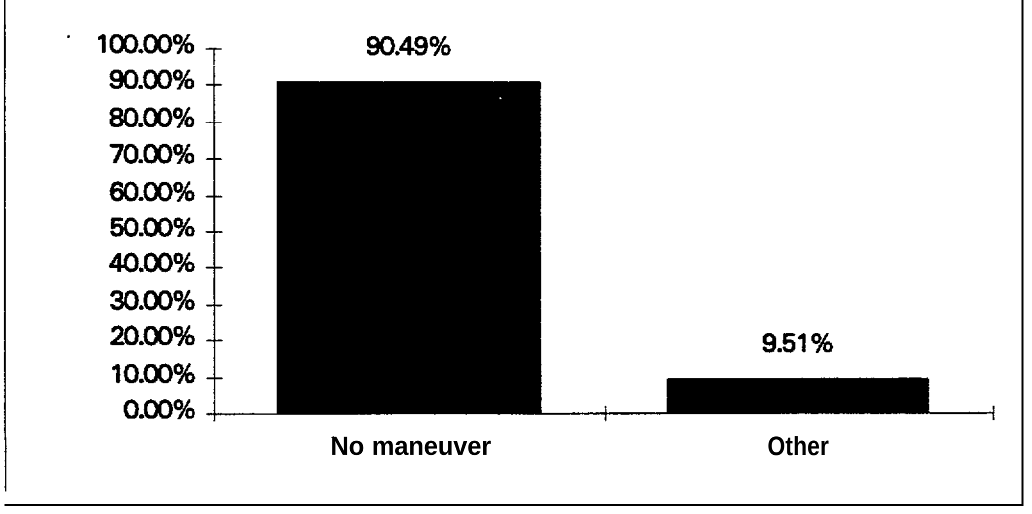

Figure 3.1-23 Percent of Rear-End Collisions vs. Striking Driver Maneuver to Avoid (92 GES)

Figure 3 .1-24 shows that the striking driver is rarely distracted, again reinforcing the CDS analysis.

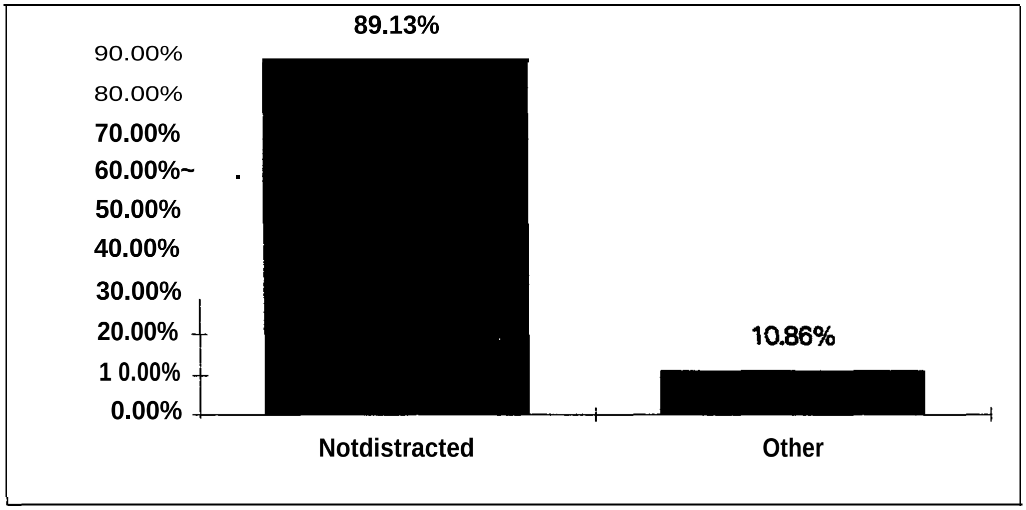

Figure 3.1-27 Percent of Rear-End Collisions vs. Striking Driver Distracted By (92 GES)

SECTION 4
SUMMARY

This report is intended to supplement the NHTSA reports cited previously. Additional statistical information presented within this report is important to some aspects of system design and analysis and in system trade-offs and benefits analysis. Data sources for this work include the NHTSA Fatal Accident Reporting System (FARS), various aspects of the National Accident Sampling System (NASS) particularly the General Estimates System (GES), state data files from Michigan, Texas, and Washington, and some reference to the literature.

The NHTSA FARS and NASS GES seem to provide the best source of information available for initial inquiry into the rear-end collision problem. Additional data used to make more subtle analysis should be obtained through the use of clinical data and use of the GES or FARS should be limited to verification of the clinical data. The NHTSA FARS database is a census and should be considered a relatively complete record of U.S. fatal accidents, and any random biases that occur within the data file are presumed small enough to be neglected. The GES database appears robust enough to allow reasonable estimates of the characteristics of the rear-end collisions. However, large discrepancies exist between databases such as the 1992 NASS GES and the 199 1 NASS CDS or MDAI files. In most cases the GES can be used to make broad reasonable estimates of the rear-end crash problem, but more subtle, or more accurate, analysis should come from in-depth review of clinical cases with a sufficiently large enough sample size to provide statistical meaning.

Also numerous discrepancies exist when new variables are introduced to any database collection. This can typically be caused by lack of instruction and guidance to the investigators, problems with providing uniquely interpreted variables, new variables contradicting other established or existing variables, or errors pertaining to entering the codes for the new variables (this is a problem even for existing variables).

The following recommendations exist when working with any of the mass databases:

1. Increase the estimated number of police reported rear-end collisions be 15%.
2. A similar increase or decrease should be considered for the number of non-police reported rear-end collisions. Further study is required to determine a more defensible number.
3. Decrease the estimated number of "A" injuries for the southern region of the U.S. by 50% or decrease the total estimated "A" injuries in rear-end collisions by 25%.
4. Increase by 40% the GES-estimated number of rear-end collisions in urban areas and adjust the effects thereof, like time-of-day, etc.
5. For conflicts between old variables and new variables added to the mass database, err on the side of the old variables.
6. Only use the mass database to estimate broad (high) statistical meaning. For subtle analysis, and/or in-depth analysis use a clinical type database and use the mass database to verify the findings.
7. Be wary that numerous conflicts exist in the coding present within all the databases GES, CDS, etc.

This section presented the analysis of three accident data files, the 1989 NASS GES and state files from Michigan and Texas to supplement or confirm the NHTSA analysis. In most cases the results of the analysis confirmed the previous NHTSA analysis.

The results of the 1989 NASS GES analysis may be summarized as follows:

- Eighty-five percent of rear-end collisions involve only two vehicles.
- Forty-six percent occurred in areas with populations of $<25,000$ and 29% in areas with populations $>100,000$.
- Rear-end collisions were about equally split between occurring at a non-junction and at an intersection or access.
- There was about an equal split between non-divided and divided or one-way streets.
- There was about an equal split between two-lane and multiple-lane roads.
- Ninety-one percent of the collisions occurred on straight roads.
- Sixty-three percent (with unknowns equally distributed) occurred on level roads.

- Seventy percent of the rear-end accidents occurred on dry roads with 24% occurring on wet roads.
- Sixty percent occurred with no traffic control device present and 26% occurred with a stop-and-go light.
- Seventy-five percent occurred under light conditions with 14% under dark-but-lit conditions.
- Seventy-eight percent occurred under no adverse weather conditions and 16% in rain.
- Ninety-nine percent of rear-end collisions did not involve a school bus.
- Sixty-seven percent of rear-end collisions did not involve an injury and 23% had a possible injury.
- Alcohol was not involved in 95% of the rear-end collisions.

The state files confirmed these findings in areas of significance.

The 1992 NASS GES file was recently made available to the public, and this section presented an analysis to update and augment the previous analysis. The results of the analysis are summarized below. It should be noted that there are some inconsistencies between coding of essentially the same accident parameter in different variables.

- Fifty-nine percent of the lead vehicles were stopped, 24% were slower and 13% were decelerating as coded in the accident type variable.
- In the pre-crash variables, 54% of the lead vehicles were coded as stopped and 54% had no corrective action taken while 68% of the following vehicles were coded as going straight and with no corrective action in 62% of the cases. Striking driver maneuver to avoid was coded as no maneuver in 90% of the cases.
- Eighty percent of the rear-end collisions occurred in clear weather.
- Seventy-six percent occurred in light conditions.
- Seventy-three percent occurred on dry roads.
- Ninety-five percent occurred on straight roads and 76% on level roads.
- Junctions, land use, number of lanes, alcohol, vision obstructions and driver distractions were not factors in the accident.